

TITLE OF THE INVENTION

Method of and Apparatus for Manufacturing Ceramic Layered Product

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to a method of and an apparatus for manufacturing a ceramic layered product.

Description of the Background Art

10 In order to manufacture a multilayer ceramic electronic component such as a multilayer ceramic capacitor, a multilayer inductor or a multilayer circuit board, for example, raw ceramic sheets are stacked with each other to prepare a ceramic layered product. For example, a ceramic layered product for a multilayer ceramic capacitor has
15 generally been obtained by the following method or apparatus:

As shown in Fig. 10, a previously prepared mother ceramic sheet is drawn out from a sheet drawing station 1 to an electrode printing/cutting station 2, so that the mother
20 ceramic sheet is punched while electrodes are simultaneously printed on the ceramic sheets, which are punched out from the mother ceramic sheet, in this station 2. After the punching step, the mother ceramic sheet is discharged as a scrap sheet, while the ceramic sheets provided with the

electrodes are dried in a drying station 3, and thereafter stored in a sheet storage station 4.

The stored ceramic sheets are selected in response to characteristics, such as capacitance, required for a multilayer ceramic capacitor to be obtained, stacked and aligned with each other on the basis of end surfaces thereof. Then the aligned ceramic sheets are inserted in a stacking jig, and subjected to press working.

However, the aforementioned system has the following problems:

(1) A wide space is required in order to store the punched ceramic sheets.

(2) Since the electrodes are printed simultaneously with cutting of the ceramic sheets through a mechanical positioning mechanism, electrode positions are not much dispersed in the same type of electrode patterns. When the electrode patterns are exchanged, however, the electrode positions are apt to be dispersed between the different types of electrode patterns.

(3) When the electrode patterns are exchanged, it takes much time to locate the electrode patterns on cutting positions.

(4) Since the ceramic sheets are aligned with each other on the basis of end surfaces thereof, the electrode

positions of the aligned ceramic sheets still remain in the dispersed state resulting from the above item (2), to cause dispersion in capacitance of the as-obtained multilayer ceramic capacitor. Further, the electrode positions may be dispersed also by the aligning operation itself.

(5) If static electricity is generated between the ceramic sheets, or if the ceramic sheets have small thicknesses, it is difficult to align the ceramic sheets.

(6) The aligned ceramic sheets may be displaced from each other when the same are inserted in the stacking jig.

Due to such problems of the system shown in Fig. 10, it has been difficult to stack the ceramic sheets in high accuracy.

In order to solve the problems in relation to handling of the ceramic sheets in the aforementioned system, the applicant has proposed the following system, which is not yet known in the art:

As shown in Fig. 11, a sheet drawing station 5 is continuously coupled through an electrode printing station 6, a drying station 7 and a cutting/stacking station 8 to a scrap sheet winding station 9. A ceramic layered product is taken out from the cutting/stacking station 8. The feature of this system resides in that the electrode printing station 6 and the drying station 7 are provided in front of

the cutting/stacking station 8.

However, the aforementioned system has the following problems:

5 (1) This system can merely manufacture the same type of ceramic layered products in relation to electrode patterns.

(2) When the items are switched, it takes much time for setup operations such as exchange of print patterns, exchange of sheets and the like.

10 (3) There are required leader and end sheets extending beyond the length of the apparatus or the production line, to cause reduction of the material yield.

(4) Due to the continuous steps, complicated operations are required for dealing with possible defective prints and returning to the normal operation.

15 (5) In order to obtain a ceramic layered product for a multilayer ceramic capacitor, in particular, it is necessary to frequently drive and stop a printer for continuously carrying ceramic sheets provided with electrodes and those provided with no such electrodes. Thus, printing accuracy
20 is deteriorated due to irregular printing conditions.

(6) This system is improper for multi-item dab production because of the aforementioned problems (1) to (3), although the same is suitable for mass production with small setup changes.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a method of and an apparatus for manufacturing a ceramic layered product, which can stack ceramic sheets in high accuracy and advantageously cope with multi-item dab production.

According to one aspect of the present invention there is provided a method of manufacturing a ceramic layered product comprising the steps of: preparing a plurality of reels wound with a plurality of types of long mother ceramic sheets each having a plurality of electrode patterns and a plurality of registration marks, having constant positional relations to said electrode patterns, distributed along its longitudinal direction; drawing out said mother ceramic sheets from respective ones of said plurality of reels onto related sheet cutting stages; punching a region including at least one of said electrode patterns from a selected one of said mother ceramic sheets, being provided on a selected said sheet cutting stage, on the basis of said registration marks by a cutting edge of a cutting head; carrying the ceramic sheet punched out from said mother ceramic sheet by said cutting head to a stacking jig and stacking said ceramic sheet on said stacking jig; and repeating said punching, carrying and stacking to form said layered product.

According to another aspect of the present invention, there is provided an apparatus for manufacturing a ceramic layered product comprising: a reel stand for holding a plurality of reels wound with a plurality of types of long mother ceramic sheets, each having a plurality of electrode patterns and a plurality of registration marks, having constant positional relations to said electrode patterns, distributed along its longitudinal direction in parallel with each other; a plurality of sheet cutting stages for positioning said mother ceramic sheets drawn out from the respective ones of said plurality of reels respectively; a stacking jig for stacking ceramic sheets obtained by punching a region including at least one of said electrode patterns from one of said mother ceramic sheets thereon; a cutting head being movable between said plurality of sheet cutting stages and said stacking jig and having a cutting edge for punching regions of said mother ceramic sheets including said electrode patterns, said cutting head being adapted to carry ceramic sheets punched out from said mother ceramic sheets; and an optical sensor for detecting positions of said registration marks on said mother ceramic sheets and providing positioning control signals to position said cutting head to punch said regions of said mother ceramic sheets.

According to the present invention, the mother ceramic sheets provided with the electrode patterns are once taken up on the reels. Thus, it is possible to store the mother ceramic sheets provided with the electrode patterns in the states wound on the reels, and the step of forming the electrode patterns by printing etc. can be divided with respect to the later sheet cutting and stacking steps.

In the sheet cutting and stacking steps, a plurality of types of reels are set to punch out an arbitrary number of ceramic sheets from an arbitrary one of the mother ceramic sheets wound on the reels in accordance with a prescribed program, and then the ceramic sheets are stacked with each other.

In the sheet cutting step, positions for punching the mother ceramic sheets are corrected on the basis of the registration marks, which are simultaneously printed with the electrode patterns in constant positional relations thereto, in order to cut the ceramic sheets.

After the mother ceramic sheet is punched by the cutting head, the ceramic sheets are directly carried by the cutting head and stacked with each other on the stacking jig.

According to the present invention, the mother ceramic

5 sheets provided with the electrode patterns are once taken up on the reels so that the same can be divided for the later sheet cutting and stacking steps. Thus, it is possible to prepare the mother ceramic sheets provided with the electrode patterns in a mass even for multi-item dab production, thereby improving the material yield.

10 Since the mother ceramic sheets are stored in the states wound on the reels, the ceramic sheets can be easily handled to reduce the time required for exchanging the mother ceramic sheets for switching the items etc.

15 Further, it is possible to stack ceramic sheets having different types of electrode patterns with each other in arbitrary order by setting a plurality of types of reels wound with a plurality of types of mother ceramic sheets respectively. In addition, it is possible to set reels and mother ceramic sheets for a subsequent lot on nonused reel stand and sheet cutting stages, so that the setup time can be reduced to advantageously cope with multi-item dab production.

20 Since the ceramic sheets are punched out on the basis of the registration marks which are formed in constant positional relations to the electrode patterns and then stacked with each other, it is possible to stack ceramic sheets generating static electricity therebetween or those

having extremely small thicknesses, dissimilarly to the conventional system of aligning the ceramic sheets with each other on the basis of end surfaces thereof. When the electrode patterns and the registration marks are simultaneously formed by printing, print patterns therefor may simply be adjusted so that the registration marks come into the visual field of an optical sensor such as a CCD camera. Thus, the time for exchanging the print patterns is reduced.

The ceramic sheets are punched out from the mother ceramic sheet by the cutting head on the basis of the registration marks, directly carried by the cutting head onto the stacking jig, and stacked with each other on the stacking jig. Therefore, it is possible to prevent errors which may be caused before the cut ceramic sheets are inserted in the stacking jig.

Thus, the ceramic sheets can be stacked with each other in high accuracy, to enable manufacturing of a high capacity multilayer ceramic capacitor, for example.

If defective prints are caused in the electrode patterns which are formed by printing, the mother ceramic sheets may simply be moved to skip such defective prints, in order to readily cope with such troubles.

The above and further features of the present invention are set forth with particularity in the appended claims and will

become clearer from consideration of the following detailed description of an exemplary embodiment of the invention given with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing an exemplary production line for a ceramic layered product, including an embodiment of the present invention;

Fig. 2 is a plan view showing a part of a mother ceramic sheet 12;

Fig. 3 is a perspective view showing a cutting/stacking device 22;

Fig. 4 is a sectional view showing a structure employed for a sheet cutting stage 25;

Fig. 5 is a perspective view showing a stacking jig 34;

Fig. 6 is a front elevational view illustrating a conveyor 36 and a structure related thereto;

Figs. 7, 8 and 9 are front elevational views for illustrating operations of a cutting head 52 and CCD cameras 49 and 50;

Fig. 10 is a block diagram showing a conventional production line for a ceramic layered product, which is of interest to the present invention; and

Fig. 11 is a block diagram showing a production line

for a ceramic layered product, proposed by the applicant, which is not yet known in the art.

DETAILED DESCRIPTION OF AN EMBODIMENT

Fig. 1 schematically illustrates an exemplary production line for a multilayer ceramic capacitor, to which an embodiment of the present invention is applied.

Referring to Fig. 1, a long mother ceramic sheet, which is prepared by a well-known method, is set in a sheet drawing station 10, and drawn out therefrom toward an electrode printing station 11. The mother ceramic sheet may be prepared from a ceramic green sheet which is backed by an appropriate reinforcing sheet, or from an independent ceramic green sheet.

In the electrode printing station 11, a plurality of electrode patterns 14, each including a plurality of electrodes 13, are printed on the mother ceramic sheet 12 as shown in Fig. 2. The plurality of electrode patterns 14 are distributed along the longitudinal direction of the mother ceramic sheet 12. Simultaneously with such printing of the electrode patterns 14, registration marks 15 having constant positional relations to the electrode patterns 14 are printed on the mother ceramic sheet 12.

The electrode patterns 14 and the registration marks 15 printed in the aforementioned manner are thereafter dried in

a drying station 16.

Then, the mother ceramic sheet is wound on a reel in a sheet winding station 17.

5 In such a manner, a plurality of types of reels, which are wound with a plurality of types of mother ceramic sheets respectively, are prepared at need. The reels wound with the mother ceramic sheets are stored in a sheet storage station 18.

10 Then, necessary ones are selected from the plurality of types of reels which are stored in the sheet storage station 18, and set in a cutting/stacking station 19. In the cutting/stacking station 19, regions 20 including the electrode patterns 14 are punched from each mother ceramic sheet 12 as shown in Fig. 2, so that ceramic sheets punched
15 out from the mother ceramic sheet 12 are stacked with each other.

A ceramic layered product, which is formed by the stacked ceramic sheets, is then pressed in a pressing station 21.

20 The cutting/stacking station 19 is now described in detail with reference to Figs. 3 to 9.

Fig. 3 is a perspective view showing the overall structure of a cutting/stacking device 22 which is employed in the cutting/stacking station 19.

The cutting/stacking device 22 comprises a reel stand 24 for setting six reels 23, for example, which are selected from the plurality of types of reels stored in the sheet storage station 18 shown in Fig. 1, in parallel with each other. While Fig. 3 illustrates the reels 23 as containers in the form of equilateral square poles, the reels are rotatably stored within such containers in practice, so that the mother ceramic sheets 12 are drawn out from openings provided in parts of the containers.

The mother ceramic sheets 12 drawn out from the reels 23 are positioned on sheet cutting stages 25 respectively. Fig. 4 shows the structure of each sheet cutting stage 25.

Referring to Fig. 4, each sheet cutting stage 25 includes a belt conveyor mechanism which is formed by a mesh belt 26. The mesh belt 26 is extended along three rollers 27, 28 and 29, and is intermittently driven to move the mother ceramic sheet 12 along the arrow 30. When the mother ceramic sheet 12 is on a horizontally directed path, a suction device 31 vacuum-sucks the mother ceramic sheet 12 through the mesh belt 26, thereby positioning the same. This sheet cutting stage 25 is adapted to punch the regions 20 (Fig. 2) of the mother ceramic sheet 12 including the electrode patterns 14 when the ceramic sheet 12 is stationary as hereinafter described in detail, while a resulting scrap sheet 32 is cut into pieces by a cutter 33 every intermittent feed.

Referring again to Fig. 3, stacking jigs 34 are arranged in the vicinity of the sheet cutting stages 25. Fig. 5 is an enlarged view showing each stacking jig 34, which is adapted to stack a prescribed number of ceramic sheets 35 obtained by punching out the regions 20 including the electrode patterns 14 from the mother ceramic sheet 12. The stacking jig 34 comprises a bottom wall, and a frame for peripherally enclosing the ceramic sheets 35 which are stacked on the bottom wall.

As shown in Fig. 3, the stacking jigs 34 are placed on a conveyor 36. A loading rack 37 is arranged on the upstream side of the conveyor 36 in order to supply the stacking jigs 34 to the conveyor 36, while an unloading rack 38 is arranged on the downstream side of the conveyor 36 in order to take out the stacking jigs 34 from the conveyor 36. Fig. 6 also shows the conveyor 36, the loading rack 37 and the unloading rack 38.

Referring to Figs. 3 and 6, a plurality of vacant stacking jigs 34 receiving no ceramic sheets are placed on respective stages of the loading rack 37. As shown by the arrow 39, the respective stages of the loading rack 37 are displaced to be successively aligned with the upper surface of the conveyor 36. When a prescribed stage is aligned with the upper surface of the conveyor 36, an extruding cylinder

40 is driven along the arrow 41 to extrude the vacant stacking jig 34 onto the conveyor 36. The stacking jig 34 thus placed on the conveyor 36 is driven by the conveyor 36 along the arrow 42, and carried toward a prescribed position on the conveyor 36. At this prescribed position, the ceramic sheets 35 are stacked on the stacking jig 34 as shown in Fig. 5.

After the ceramic sheets 35 are stacked on the stacking jig 34, the conveyor 36 is driven along the arrow 42, to carry the stacking jig 34 to a position immediately ahead of the unloading rack 38. At this position, a vertical cylinder 45 is driven to move a push-in pawl 43 along the arrow 44 while a push-in cylinder 47 is driven to move the vertical cylinder 45 along the arrow 46. Thus, the stacking jig 34 is pushed onto a prescribed stage of the unloading rack 38. As shown by the arrow 48, the respective stages of the unloading rack 38 are displaced to be successively aligned with the upper surface of the conveyor 36. Thus, the unloading rack 38 is adapted to store a plurality of stacking jigs 34 receiving the stacked ceramic sheets 35. The unloading rack 38 filled up with the stacking jigs 34 is detached from the cutting/stacking device 22, so that the stacking jigs 34 are carried to a next step, i.e., the pressing station 21 shown in Fig. 1, with the unloading rack

38.

Referring to Fig. 3, CCD cameras 49 and 50 are arranged above the sheet cutting stages 25, in order to detect the positions of the registration marks 15 which are provided on the mother ceramic sheet 12. In order to punch the regions 20 (Fig. 2) of the mother ceramic sheets 12 including the electrode patterns 14, a cutting head 52, whose periphery is enclosed with a cutting edge 51, is arranged in the vicinity of the CCD cameras 49 and 50.

According to this embodiment, the cutting head 52 and the CCD cameras 49 and 50 are mounted on an XY θ robot 53, so that the same are movable in directions X, Y and θ . The cutting head 52 and the CCD cameras 49 and 50 may alternatively be driven by separate driving systems.

Figs. 7, 8 and 9 show operations of the cutting head 52 and the CCD cameras 49 and 50.

As shown in Fig. 3, the mother ceramic sheets 12 are drawn out from the plurality of reels 23 onto related sheet cutting stages 25 and fixed thereto respectively. As hereinabove described, this operation is achieved by the structure shown in Fig. 4. Fig. 7 shows a state corresponding to this.

Then, a prescribed one is selected from the plurality of mother ceramic sheets 12, and the XY θ robot 53 is so

driven that the registration marks 15 provided on the selected mother ceramic sheet 12 come into the visual fields of the CCD cameras 49 and 50, as shown in Fig. 7. The CCD cameras 49 and 50 image-process the positions of the registration marks 15. The results of such image processing are applied to a computer (not shown), which in turn calculates corrected values as to the positions for punching the mother ceramic sheet 12.

Then, as shown in Fig. 8, the XY θ robot 53 is driven in consideration of the aforementioned corrected values, to move the cutting head 52 toward the mother ceramic sheet 12. Thus, the regions 20 provided with the electrode patterns 14 as shown in Fig. 2 are punched. The punched ceramic sheets, which are hidden by the cutting edge 51 and not shown in Fig. 8, are carried by the cutting head 52. In order to ensure such carriage, the cutting head 52 comprises a function (not shown) for vacuum-sucking the punched ceramic sheets.

As shown in Fig. 9, the cutting head 52 is driven by the XY θ robot 53 to carry the ceramic sheets onto the stacking jig 34 which is placed on the conveyor 36, and stacks the ceramic sheets with each other on the stacking jig 34.

The aforementioned operations are repeated so that

arbitrary ceramic sheets are stacked on the stacking jig 34 in arbitrary order.

5 In order to obtain a ceramic layered product for a multilayer ceramic capacitor, it is necessary to also stack ceramic sheets which are provided with no electrode patterns. Therefore, preferably at least one of the reels 23 set on the reel stand 24, i.e., a mother ceramic sheet 12(a) which is drawn out from a reel 23(a), is provided with no electrode patterns etc., as shown in Fig. 3. In this case, the mother ceramic sheet 12(a) may simply be drawn out at a constant pitch since it is not necessary to correctly position the mother ceramic sheet 12(a) for punching.

10 As hereinabove described, the prescribed ceramic sheets 35 which are stacked on the stacking jig 34 are subjected to hydrostatic pressing, for example, in the pressing station 21 shown in Fig. 1, and thereafter cut to obtain single chips for multilayer ceramic capacitors. Then each chip is fired and provided with external electrodes, to obtain a desired multilayer ceramic capacitor.

20 In the aforementioned embodiment, the reels 23 are stored in containers, so that the mother ceramic sheets 12 can be easily stored in clean states. However, if such an advantage is not desired, it is not necessary to store the reels in containers.

The present invention is not restricted to manufacturing of a ceramic layered product for a multilayer ceramic capacitor, but is also applicable to manufacturing of layered products for other types of multilayer ceramic electronic components such as a multilayer inductor, a multilayer LC filter, a multilayer circuit board, and the like.

Having thus described the invention by reference to a particular embodiment, it is to be appreciated that the described embodiment is exemplary only and is susceptible to modification and variation without departure from the scope of the invention as determined by the appended claims.



CLAIMS:

1. A method of manufacturing a ceramic layered product comprising the steps of:

5 preparing a plurality of reels wound with a plurality of types of long mother ceramic sheets each having a plurality of electrode patterns and a plurality of registration marks, having constant positional relations to said electrode patterns, distributed along its longitudinal direction;

10 drawing out said mother ceramic sheets from respective ones of said plurality of reels onto related sheet cutting stages;

15 punching a region including at least one of said electrode patterns from a selected one of said mother ceramic sheets, being provided on a selected said sheet cutting stage, on the basis of said registration marks by a cutting edge of a cutting head;

20 carrying the ceramic sheet punched out from said mother ceramic sheet by said cutting head to a stacking jig and stacking said ceramic sheet on said stacking jig; and

repeating said punching, carrying and stacking to form said layered product.

25 2. A method as claimed in claim 1, wherein said punching and stacking are carried out on a plurality



of regions from a selected mother sheet.

3. A method as claimed in claim 1, wherein said punching is carried out on a plurality of regions from a plurality of mother sheets and said stacking the ceramic sheets on said stacking jig is carried out in a desired sequence.

4. A method as claimed in any one of the preceding claims, wherein said registration marks are printed onto said long mother ceramic sheets.

5. A method as claimed in any one of the preceding claims, wherein the cutting head is aligned with a region to be punched by aligning an optical sensor fixed to said cutting head with said registration marks.

6. A method as claimed in any one of the preceding claims including providing a reel containing a blank long mother ceramic sheet not having electrode patterns printed thereon.

7. A method of manufacturing a ceramic layered product in accordance with any one of the preceding claims, wherein said step of preparing a plurality of



reels comprises a step of storing a plurality of reels containing different types of long mother ceramic sheets and a step of selecting ones of said reels from said stored plurality of reels.

5 8. A method of manufacturing a ceramic layered product in accordance with claim 7, wherein said step of storing said plurality of reels comprises a step of storing said reels in containers.

10 9. A method of manufacturing a ceramic layered product in accordance with any one of the preceding claims, wherein said mother ceramic sheets are intermittently drawn out in said step of drawing out said mother ceramic sheets from said reels, and said
15 step of punching said one of said mother ceramic sheets by said cutting head is carried out when said mother ceramic sheet is stationary.

20 10. A method of manufacturing a ceramic layered product in accordance with claim 9, further comprising a step of cutting a scrap sheet resulting from said step of punching said one of said mother ceramic sheets by said cutting head every intermittent feed of said mother ceramic sheet.



11. An apparatus for manufacturing a ceramic layered product comprising:

5 a reel stand for holding a plurality of reels wound with a plurality of types of long mother ceramic sheets, each having a plurality of electrode patterns and a plurality of registration marks, having constant positional relations to said electrode patterns, distributed along its longitudinal direction in parallel with each other;

10 a plurality of sheet cutting stages for positioning said mother ceramic sheets drawn out from the respective ones of said plurality of reels respectively;

15 a stacking jig for stacking ceramic sheets obtained by punching a region including at least one of said electrode patterns from one of said mother ceramic sheets thereon;

20 a cutting head being movable between said plurality of sheet cutting stages and said stacking jig and having a cutting edge for punching regions of said mother ceramic sheets including said electrode patterns, said cutting head being adapted to carry ceramic sheets punched out from said mother ceramic sheets; and

25 an optical sensor for detecting positions of said registration marks on said mother ceramic sheets and



providing positioning control signals to position said cutting head to punch said regions of said mother ceramic sheets.

5 12. An apparatus as claimed in claim 11, wherein the optical sensor is mounted to the cutting head.

13. An apparatus as claimed in claim 12, wherein the optical sensor comprises two CCD cameras positioned on said cutting head so as to be aligned with said registration marks when said cutting head is aligned
10 with a region of a mother ceramic sheet to be punched.

14. An apparatus as claimed in any one of claims 11 to 13, wherein the registration marks are printed on the long mother ceramic sheets.

15 15. An apparatus as claimed in any one of claims 11 to 14 including a reel containing a blank long mother ceramic sheet, not having electrodes printed thereon.

16. An apparatus for manufacturing a ceramic layered product in accordance with any one of claims 11 to 15, wherein said sheet cutting stages include conveyor
20 means for intermittently carrying said mother ceramic sheets.



17. An apparatus for manufacturing a ceramic layered product in accordance with claim 16, wherein each said conveyor means comprises a mesh belt being intermittently driven while carrying each said mother ceramic sheet thereon and a suction device to suck said mother ceramic sheet through said mesh belt.

18. An apparatus for manufacturing a ceramic layered product in accordance with any one of claims 11 to 17, wherein said stacking jig comprises a bottom wall and a frame for peripherally enclosing said ceramic sheets stacked on said bottom wall.

19. An apparatus for manufacturing a ceramic layered product in accordance with any one of claims 11 to 18 further comprising conveyor means for carrying said stacking jig.

20. An apparatus for manufacturing a ceramic layered product in accordance with any one of claims 11 to 19 further comprising an XYθ robot for moving both said optical sensor and said cutting head.

21. A method or apparatus substantially as described herein with reference to Figures 1 to 9 of the accompanying drawings.