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OSTROLENK, FABER --- MURATA MANUFACT

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REPLACED SHEETS SG

final version

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METHOD OF MANUFACTURING A MULTILAYER CAPACITOR.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of manufacturing a multilayer capacitor having a number of green sheets stacked with internal electrodes provided thereon and, more particularly, to a manufacturing method which can improve the accuracy of the capacitance of such a capacitor.

2. Description of the Related Art

The manufacture of multilayer capacitors is generally carried out by employing a method wherein, as shown in Fig. 4 (which shows an embodiment of the invention), internal electrodes 2 are printed and dried on the surface of ceramic green sheets 1; thereafter, the green sheets 1 are stacked in a quantity corresponding to the capacitance to be obtained, with, if necessary, a green sheet having a correction pattern 3 provided thereon; heating and firing is performed; and external electrodes 4 are provided on both ends of the product.

The capacitance obtained in such multilayer capacitors, and variations of the same, are primarily determined by the electrode area occupied by the internal electrodes 2 after they are printed and dried on the ceramic green sheets 1.

During the manufacture of a multilayer ceramic capacitor, the number of green sheets having internal electrodes thereon to be stacked to obtain a given capacitance has conventionally been determined by sampling the sheets in a production lot after the

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internal electrodes are printed and dried on a mother
green sheet, to obtain a representative value of the area
of a printed internal electrode, and by thereafter
determining the number of green sheets to be stacked
5 having ~~main patterns~~ 2 provided thereon and the area of
an electrode 3 to be provided on a correction ~~sheet~~.

However, the area of the internal electrodes
depends on the degree of the expansion and contraction of
the ceramic sheets. Specifically, the degree of the
10 expansion and contraction of the ceramic sheets varies
depending on the water content of the ceramic sheets and
external forces applied during the storage of the sheets,
which causes variations in the area of the internal
electrodes. This has resulted in a problem in that it
15 is difficult to control the capacitance accurately on a
production lot basis by setting and correcting the number
of sheets to be stacked using a representative value of
such an area.

Especially, in light of a recent trend toward
20 more compact and higher precision multilayer ceramic
capacitors, a change in capacitance due to the
accumulation of errors in the area of the internal
electrodes results in a problem in the case of capacitors
that must have high precision in that the yield of the
25 products is decreased.

Further, the method of determining the number
of green sheets to be stacked from a representative value
of the area of an internal electrode obtained by
performing sampling on a production lot has resulted in a
30 problem, especially in the case of a large production
lot, in that the sampling can not be finished until all
of the internal electrodes in the lot are printed and
dried, which increases the amount of work in process.

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It is therefore an object of the present invention to provide a method of manufacturing multilayer capacitors wherein the accuracy of the capacitance and the yield of the products can be improved, by obtaining
5 the number of green sheets to be stacked having internal electrodes provided thereon, and a correction amount for a correction pattern, on a block-by-block basis, from the area of the electrodes obtained by measuring block-by-block all or a plurality of the electrodes, after they
10 are printed and dried.

SUMMARY OF THE INVENTION

In order to solve the problems as described above, according to a first aspect of the invention, a method is employed wherein after internal electrodes are
15 printed and dried on green sheets, the area of the electrodes is obtained by sampling all of the sheets or a part of each sheet or one sheet from among several sheets on a block-by-block basis, i.e., by sampling a limited number of sheets which are to be included in a block, and
20 wherein the number of the green sheets having the internal electrodes provided thereon which are to be stacked in a block to obtain a multilayer capacitor with a given capacitance is obtained from the area of the electrodes on each sheet thus obtained for that block.

25 According to a second aspect of the present invention, a method is employed wherein after internal electrodes are printed and dried on green sheets, the area of the electrodes on all the sheets is obtained on a block-by-block basis; the number of the green sheets
30 having the internal electrodes provided thereon to be stacked to obtain a set capacitance of a multilayer capacitor, and the area or a shifting amount of an

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formed with
internal electrodes

an internal electrode for correction

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5 electrode on ~~a correction pattern~~, are determined from the area of the electrodes on each sheet; and the green sheets having the internal electrodes provided thereon and a green sheet having the ~~correction pattern~~ thereon are stacked to form a block. *internal electrode for correction*

10 The area of the internal electrodes on all of the ceramic green sheets is obtained on a block-by-block basis after the internal electrodes are printed and dried on the ceramic green sheets. The number of the sheets ~~having patterns~~ to be stacked and the electrode area or shifting amount of the ~~correction sheet~~ are obtained for each block ~~from~~ the area of the electrodes on each sheet.

based on

15 The ~~correction sheet~~ is stacked on the sheets ~~having the main patterns~~ provided thereon to create a block. This makes it possible to provide capacitors with a highly accurate capacitance, thereby improving the yield of the products. *internal electrode for correction*

20 Further, production efficiency is improved because the printing and drying of the internal electrodes, the measurement of the area of the internal electrode, and the creation of blocks can be carried out continuously. *for correction*

sheet provided with internal electrodes

provided with the internal electrodes

BRIEF DESCRIPTION OF THE DRAWINGS

25 Fig. 1 is a flow chart showing processing steps according to an embodiment of the present invention.

Figs. 2(A), 2(B), 2(C), and 2(D) illustrate different examples of an area measuring method.

Fig. 3(A) is a front view of an apparatus in which the present invention is implemented.

30 Fig. 3(B) is a sectional view of a ceramic green sheet.



Internal electrode for correction
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Fig. 4 is a sectional view of a multilayer capacitor obtained by the method.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

An embodiment of the present invention will now be described with reference to the drawings. (piled)

Fig. 1 is a flow chart showing processing steps according to a manufacturing method according to the present invention. After internal electrodes are printed and dried on the surface of ceramic green sheets, the areas of the electrodes on all of the ceramic green sheets are determined. A predetermined number of green sheets are stacked and laminated to form a block, and the lamination of a block is terminated when a predetermined capacitance is obtained by this number of stacked sheets.

When the capacitance obtained by the above-mentioned number of sheets is insufficient, the area of a ~~correction pattern~~ is obtained; the ~~correction pattern~~ is printed based on 10; and green sheets having such an ~~correction pattern~~ provided thereon are stacked to terminate the lamination of a block.

As shown in Fig. 4, according to the manufacturing method including the above-described processing steps, a multilayer ceramic capacitor is provided by stacking ceramic green sheets 1 having internal electrodes 2 printed thereon in a quantity corresponding to a given capacitance, stacking a ceramic green sheet having a ~~correction pattern~~ 3 for fine tuning printed thereon, and heating and firing the same.

Figs. 2(A) through 2(D) show different examples of a method of directly measuring the areas of internal electrodes 2 printed and dried on a ceramic green sheet.

an internal electrode for correction

internal electrode for correction

based on the capacitance value insufficient.



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CCD or an optical

Fig. 2(A) shows a method of measuring area wherein the internal electrode is photographed with a camera 5 and the resultant image is analyzed by a processor 6.

5 Fig. 2(B) shows a method wherein an optical device 7 scans a sheet two-dimensionally and measurement is performed using an A-D converter 8 and a processor 9.

10 Fig. 2(C) shows a method wherein an optical device array 10 scans a sheet one-dimensionally and measurement is performed using an A-D converter 11 and a processor 12.

15 In each of the above measuring methods, there need not be only one camera 5, optical device 7, or optical device array 10, but rather the measurement may be performed using a plurality of such components.

20 Fig. 2(D) shows a method wherein sensing marks 13 are provided at two or more points on the ceramic green sheet 1 simultaneously with the printing of the internal electrodes; the distance between the marks 13 is measured using the methods shown in Figs. 2(A) through 2(C); and the expansion and contraction of the ceramic green sheet 1 is calculated from the measured value to obtain the areas of the internal electrodes indirectly.

25 Methods of correcting the areas of internal electrodes include (1) a method wherein a correction process is performed on the area of the opening for the electrode in the printing pattern for the internal electrode and (2) a method wherein a correction process is performed on the area of the electrode formed on the sheet immediately after the printing of the internal electrode, wherein data representative of the area has been separately maintained.

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That is, the internal electrode and the internal electrode for correction can be formed by one electrode.

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Another method is to obtain the outside dimensions of the ceramic green sheet optically or physically and to determine the expansion and contraction of the sheet by comparing such values obtained before and after drying, thereby obtaining the areas of the internal electrodes indirectly.

Fig. 3(A) illustrates an apparatus wherein the manufacturing method according to the present invention is implemented. A dryer 23 for heating and drying a ceramic green sheet 1 passing therethrough is provided in the middle of the path traveled by the sheet 1 which is pulled out from a reel 21 and taken up by a take-up reel 22. A printing head 24 for printing internal electrodes is provided in a position upstream of the dryer 23. An area measuring machine 25; a machine 26 for shift-punching and stacking the sheet 1; and a metal mold 27 provided opposite to the stacking machine 26 across the sheet 1 for receiving the punched sheets 1 in a stacked state, are provided downstream from the dryer.

The result of the measurement performed by the area measuring machine 25 on the internal electrode is inputted to a processor 28 which in turn activates the printing head 24 and shift-punching and stacking machine 26 to print the internal electrodes on the ceramic sheets 1 and to stack the sheets 1 by punching them automatically. *an internal electrode for correction*

Further, ~~a correction pattern~~ can be formed by changing the printing position of the printing head 24, or shifting the punching position of the stacking machine 26. *of the internal electrode*

As shown in Fig. 3(B), the ceramic green sheet 1 is formed on a synthetic resin film 29 to a predetermined thickness.

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The method of manufacturing a multilayer capacitor will now be described with reference to Fig. 3(A).

5 The internal electrodes 2 are printed by the printing head 24 on the ceramic green sheet 1 pulled out from the reel 21 before it enters the dryer 23, and the internal electrodes are dried as the sheet 1 passes through the dryer 23 thereafter.

10 The ceramic green sheet 1 contracts as a result of the drying after the printing of the internal electrode, which results in a change in the area of the internal electrodes from a value at the time of the printing to a value after the drying.

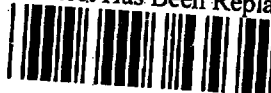
15 When the ceramic green sheet 1 exits the dryer 23, the area of the internal electrodes is sequentially measured by the area measuring machine 25 and is inputted to the processor 28. A capacitance to be obtained for a capacitor is inputted in the processor in advance, and the processor performs integration each time an area of
20 an internal electrode is inputted to calculate the number of layers and operates the stacking machine 26 to punch the sheets and to stack them up in the metal mold 27.

25 The area of the internal electrodes is sequentially measured by the area measuring machine 25, and the punching by the stacking machine 26 is repeated until the number of the sheets to be stacked, which is obtained from the cumulative area, reaches the capacitance to be obtained, so that the sheets are
30 stacked in the metal mold 27 in a quantity corresponding to the capacitance to be obtained.

In this case, the stacking may be performed by obtaining the area of the electrodes on all sheets or may alternatively be performed based on the area of

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Sheet provided with the
internal electrode for
correction

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a sheet provided with
an internal electrode
for correction

electrodes obtained by carrying out sampling on the
electrodes or sheets at a frequency of about 10 % or
more.

Further, if it is required to perform fine
5 tuning of the capacitance to be obtained, ~~a correction~~
~~sheet~~ is created by obtaining a shifting amount for the
correction sheet to shift the position for sheet punching
by the stacking machine 26, and the ~~correction sheet~~ is
10 stacked on the green sheets having the ~~main patterns~~
provided thereon. *internal electrodes*

A block is created by stacking up the green
sheets having main patterns provided thereon and the
green sheet having a correction pattern provided thereon
as described above and is integrated into a multilayer
15 structure which is in turn cut and fired and is provided
with external electrodes to provide a multilayer
capacitor having a capacitance which agrees with the
target capacitance.

As described above, according to the present
20 invention, the area of all or a plurality of the internal
electrodes is obtained to determine the number of green
sheets having the internal electrodes thereon to be
stacked to obtain a set capacitance of a multilayer
capacitor. This eliminates factors which can cause
25 variation in capacitance due to variation in the area of
the internal electrodes and therefore allows the accuracy
of capacitance and the yield of the products to be
improved.

In addition, since the processes from the
30 printing of the internal electrodes on the green sheets
through the creation of a block can be continuously
performed, the efficiency of the manufacture of
capacitors can be improved.

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In this case, the shape of the internal electrode
is the same as that of the internal electrode for
correction.

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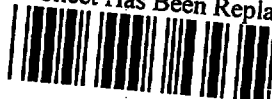
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5 While a particular embodiment of the present invention has been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as fall within the true spirit and scope of this invention.

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WHAT IS CLAIMED IS:

1. A method of manufacturing a multilayer capacitor with a predetermined capacitance by stacking in a block a predetermined number of green sheets each having an internal electrode on one side thereof,
5 comprising the steps of:
measuring the area of said electrode by sampling on a block-by-block basis after the internal electrodes are printed and dried on the green sheets; and
10 determining the number of the green sheets having the internal electrodes provided thereon to be stacked to obtain said predetermined capacitance, on the basis of the area of the electrode on each sheet thus obtained.
2. A method as in claim 1, wherein said sampling is carried out on all the sheets of at least one block.
3. A method as in claim 1, wherein said sampling is carried out on a part of each sheet of at least one block.
4. A method as in claim 3, wherein at least 10 percent of each sheet is sampled.
5. A method as in claim 1, wherein said sampling is carried out on at least one sheet selected from among several sheets of at least one block.
6. A method as in claim 5, wherein at least 10 percent of said sheets are sampled.

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7. A method as in claim 1, further comprising the step of stacking said number of green sheets having the internal electrodes provided thereon.

8. A method as in claim 7, wherein said number is determined by sequentially integrating the electrode areas thus measured until said predetermined capacitance is reached in the green sheets thus stacked.

9. A method as in claim 1, wherein said area is measured by a method selected from the group consisting of direct and indirect methods.

10. A method of manufacturing a multilayer capacitor with a predetermined capacitance by stacking in a block a predetermined number of green sheets each having an internal electrode on one side thereof, comprising the steps of:

measuring the area of said internal electrodes on all of the green sheets on a block-by-block basis after the electrodes are printed and dried on the green sheets; determining the number of the laminated green sheets having the internal electrodes provided thereon to be stacked to obtain said predetermined capacitance, and a characteristic of a correction electrode on a ~~correction pattern~~, on the basis of the electrode area on each sheet; and

stacking the green sheets having the internal electrodes provided thereon and a green sheet having the ~~correction pattern~~ thereon.

internal electrode for correction

an internal electrode for correction

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11. A method as in claim 10, wherein said area is measured by sampling all of the sheets of at least one block.

12. A method as in claim 10, wherein said area is measured by sampling a part of each sheet of at least one block.

13. A method as in claim 12, wherein at least 10 percent of each sheet is sampled.

14. A method as in claim 10, wherein said area is measured by sampling at least one sheet selected from among several sheets of at least one block.

15. A method as in claim 14, wherein at least 10 percent of said sheets are sampled.

16. A method as in claim 10, wherein the area of a correction electrode is determined in said determining step.

17. A method as in claim 10, wherein a shifting amount of a correction electrode is determined in said determining step.

18. A method as in claim 10, wherein said number is determined by sequentially integrating the electrode areas thus measured until said predetermined capacitance is reached in the green sheets thus stacked.

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19. A method as in claim 10, wherein said area is measured by a method selected from the group consisting of direct and indirect methods.

20. A method as in claim 1, wherein said internal electrode is used as an internal electrode for correction. ✓

21. A method as in claim 10, wherein one of said internal electrodes is used as an internal electrode for correction. ✓

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