

PRODUCTION METHOD OF ELECTRONIC COMPONENTS

Background of the Invention

Field of the Invention

The present invention relates to a production method of electronic components.

Description of the Prior Art

As an example of conventional production methods of electronic components, a production method for a conventional multilayer ceramic capacitor will be explained with reference to FIG. 1. FIG. 1 is a cross-sectional view of a multilayer ceramic capacitor. The production method is disclosed in P. 54-P. 59 of "Multilayer ceramic capacitor" published by Gakkensha on September 26, 1988. As shown in FIG. 1, the multilayer ceramic capacitor comprises a capacitor element 7 which is an electronic component elements assembly of dielectric ceramics 1 and internal electrodes 2 alternately laminated, and external electrodes 3 connected with the internal electrodes 2.

The external electrodes 3 are formed, for example, in the steps comprising applying a conductive paste mainly comprising silver or silver-palladium alloy on the capacitor element 7 followed by baking so as to form a first external

electrode 4, forming a second external electrode 5 with a conductive layer such as nickel on the first external electrode 4 with a wet plating method, and forming a third external electrode 6 with a conductive layer such as tin or solder on the second external electrode 5 with a wet plating method.

The first external electrode 4 is formed with silver or a conductive material comprising silver, which has excellent electric conductivity in order to improve the electric connection reliability with the internal electrode 2 and to provide a sufficient conductivity to the external electrode 3. The second external electrode 5 is formed with a conductive layer such as nickel, which is not susceptible to solid solution with solder in order to prevent solid solution of the first external electrode 4 at the time of soldering even though the first external electrode 4 is formed with a material containing silver, which is susceptible to solid solution. The third external electrode 6 is formed with a conductive layer such as tin or solder, which has an excellent solder wettability since the second external electrode 5 does not have a sufficient solder wettability.

The above-mentioned conventional production method, however, has a problem in that the adhering strength between the capacitor element 7 and the first external electrode 4

deteriorates at the time of forming the second external electrode 5 and the third external electrode 6 shown in FIG. 1 to cause a lower electric connection reliability with the internal electrode 2, resulting in peel-off of the external electrode 3 at the time of mounting the capacitor element 7 on a printed board.

Furthermore, in addition to the above-mentioned problem caused by the deterioration of an adhering strength, there is another problem in that a conductive layer is formed also in a portion where formation of a first external electrode 4 is not desired, resulting in short-circuit among the external electrodes 4.

SUMMARY OF THE INVENTION

Accordingly, in order to solve the above-mentioned various problems, an object of the present invention is to provide a production method of electronic components capable of improving the adhering strength between the electronic component elements assembly and the external electrodes.

A production method of electronic components of the present invention comprises the steps of preparing an electronic component elements assembly having an external electrode formation area, forming a first external electrode on the external electrode formation area of the electronic

component elements assembly, and forming a second external electrode on the first external electrode with a wet plating method using a plating liquid having dissolved oxygen eliminated.

According to the production method of electronic components of the present invention, since the second external electrode of the electronic components is formed with a wet plating method using a plating liquid having dissolved oxygen eliminated, prevention of deterioration of the adhering strength between the electronic component elements assembly and the first external electrode, improvement of electronic connection reliability with the internal electrode, and prevention of peel-off of the external electrode at the time of mounting on a printed board of the electronic components can be achieved. Besides, since reduction of the surface of the electronic component elements assembly can be prevented at the time of plating, a conductive layer is formed only in the external electrode formation area and thus an effect of preventing short-circuit among the external electrodes can also be achieved.

In the production method of electronic components of the present invention, an electroplating method is used as the wet plating method.

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present invention, an electroless plating method is used as the wet plating method.

In the production method of electronic components of the present invention, a residual oxygen concentration in the plating liquid after eliminating the dissolved oxygen is 7.0 mg/l or less.

According to the production method of electronic components of the present invention, effects of preventing deterioration of adhering strength of the first external electrodes and preventing peel-off of the external electrodes at the time of mounting on a printed board of electronic components can be further improved.

In the production method of electronic components of the present invention, dissolved oxygen in a plating liquid is eliminated by adding at least one selected from the group consisting of hydrazine, triethanol amine and sulfite to the plating liquid.

In the production method of electronic components of the present invention, dissolved oxygen is eliminated by aerating an inert gas in a plating liquid.

In the production method of electronic components of the present invention, electronic components comprise ceramic electronic components containing an oxide of at least one selected from the group consisting of titanium, bismuth, lead,

zirconia, calcium and niobium.

BRIEF DESCRIPTION OF DRAWING

FIG. 1 is a cross-sectional view of a multilayer ceramic capacitor, which is an electric component.

DESCRIPTION OF A PREFERRED EMBODIMENTS

An embodiment of the present invention will be described. The production method of electronic components relates to a method for forming an external electrode, comprising the step of forming at least one layer of a first external electrode in the external electrode formation area of an electronic component elements assembly. Examples of the method for forming at least one layer of a first external electrode include a method of applying and baking a conductive paste, a deposition method, an electroless plating method, and a sputtering method. It is preferable that the first external electrode comprises silver or a conductive material comprising silver, which has excellent electric conductivity in order to improve the electric connection reliability with an internal electrode and to provide a sufficient conductivity to an external electrode.

Then the production method of electronic components comprises the step of forming at least one layer of a second external electrode by a wet plating method using a plating

liquid having dissolved oxygen eliminated, in particular, an electroless plating method or an electroplating method. Examples of the method for eliminating dissolved oxygen include a method of aerating an inert gas such as a nitrogen gas and an argon gas in the plating liquid and a method of adding into the plating liquid a chemical substance, which chemically reacts with the dissolved oxygen in the plating liquid without an adverse effect on the precipitation reaction in the plating liquid, such as hydrazine, triethanol amine and sulfite. Furthermore, a method of heating the plating liquid or a method of contacting the surface of the plating liquid only with the above-mentioned inert gas can be used for eliminating dissolved oxygen in the plating liquid as well. It is preferable that a residual oxygen concentration in the plating liquid after eliminating dissolved oxygen is 7.0 mg/l or less.

Moreover, after the formation of the second external electrode, a third external electrode or a plurality of external electrodes comprising a material having an excellent solderability such as tin or solder can be further formed on the second external electrode. A method of forming the first external electrode can be used for forming the third external electrode, and effects of the invention can be further achieved by the use of a plating liquid having

dissolved oxygen eliminated with the above-mentioned method of eliminating dissolved oxygen in the case of using a wet plating method such as an electroless plating method or an electroplating method.

Effects of the present invention can be realized particularly in ceramic electronic components containing an oxide of at least one selected from the group consisting of titanium, bismuth, lead, zirconia, calcium and niobium, such as a ceramic capacitor, a ceramic filter, a ceramic resonator and a ceramic vibrator. However, effects of the present invention can be obtained also in an electrolytic capacitor and a ceramic substrate.

According to the embodiment, since a second external electrode of an electronic component is formed by a wet plating method using a plating liquid having dissolved oxygen eliminated, prevention of deterioration of the adhering strength between the electronic component elements assembly and the first external electrode, improvement of electronic connection reliability with the internal electrode, and prevention of peel-off of the external electrode at the time of mounting on a printed board can be achieved. Besides, since reduction of the surface of the electronic component elements assembly can be prevented at the time of plating, a conductive layer is formed only in the external electrode

formation area and thus an effect of preventing short-circuit among the external electrodes can also be achieved.

As a first example of the present invention, a production method of a multilayer ceramic capacitor will be described. A slurry was prepared from a BaO-TiO₂ containing dielectric calcinated powders with a binder, a plasticizer, and a solvent. Then a plurality of dielectric ceramic green sheets were produced in a doctor blade method therefrom. A silver paste was formed as an internal electrode pattern on the dielectric ceramic green sheets in a screen printing method, followed by bonding by pressure after lamination. Then a capacitor elements assembly was produced by cutting into pieces, and baking after removing the binder by heating.

After applied with a silver paste, the external electrode formation area of the capacitor elements assembly was baked for forming a first external electrode having a thickness of 20 μ m.

An electrolytic nickel plating liquid comprising an aqueous solution of nickel sulfate, nickel chloride and boric acid was produced as the basic plating liquid. Then electrolytic nickel plating liquids were produced by adding some hydradine, triethanol amine or sulfite to the basic plating liquid, respectively. Moreover, electrolytic nickel plating liquids were prepared by aerating the

above-mentioned basic plating liquid or added electrolytic nickel plating liquids with a nitrogen gas or an argon gas respectively in the condition of 1000 cc/minute from one hour before the electroplating treatment. With the electrolytic nickel plating liquids produced as mentioned above, an electrolytic nickel plating was conducted with a barrel plating method so as to form a nickel film having a 2 μ m thickness as a second external electrode on the first external electrode. The dissolved oxygen amount in each electrolytic nickel plating liquid was measured in a diaphragm galvanic cell method immediately before conducting the electrolytic nickel plating. A third external electrode was formed on the second external electrode by an electroplating with an alkanol sulfonic acid solder plating liquid. By the process of forming external electrodes as heretofore mentioned, a multilayer ceramic capacitor was produced.

An adhering strength between external electrodes and a capacitor elements assembly was measured in a tensile test by soldering a lead line on an external electrode and pulling perpendicular to the electrode surface.

Results are shown in Table 1. An adhering strength was improved by eliminating dissolved oxygen compared with the case without eliminating dissolved oxygen. Further, it was confirmed that an adhering strength was improved as the

dissolved oxygen reduces. A conductive layer was formed only in the first external electrode formation area. Accordingly, in a production of an electronic component in a method of the present invention, degree of eliminating the dissolved oxygen can be determined depending upon the adhering strength desired to the electronic component.

[Table 1]

Ex- peri- ment No.	Plating liquid	Aeration	Dissolved oxygen amount (mg/l)	Tensile strength (kg/mm ²)	Elimina- tion of dissolved oxygen
1	Plating liquid	No	8.7	0.5	No
2	Plating liquid + hydradine	No	3.1	1.5	Yes
3	Plating liquid + triethanol amine	No	2.8	1.4	Yes
4	Plating liquid + sulfite	No	3.5	1.5	Yes
5	Plating liquid	Nitrogen gas	0.7	2.5	Yes
6	Plating liquid + hydradine	Nitrogen gas	0.5	3.4	Yes
7	Plating liquid + triethanol amine	Nitrogen gas	0.4	3.2	Yes
8	Plating liquid + sulfite	Nitrogen gas	0.4	3.5	Yes
9	Plating liquid	Argon gas	0.9	2.6	Yes
10	Plating liquid + hydradine	Argon gas	0.4	3.8	Yes
11	Plating liquid + triethanol amine	Argon gas	0.3	3.8	Yes
12	Plating liquid + sulfite	Argon gas	0.5	3.6	Yes

Furthermore, the same results were obtained in a production method the same as above except that a second external electrode was formed with an electroless nickel plating liquid having dissolved oxygen eliminated in the above-mentioned method after conducting a catalytic activating treatment only on the first external electrode.

As a second example of the present invention, a production method of a multilayer ceramic capacitor will be described. A slurry was prepared from a $\text{Bi}_2\text{O}_3\text{-CaO-Nb}_2\text{O}_5$

containing dielectric calcinated powders with a binder, a plasticizer, and a solvent. Then a plurality of dielectric ceramic green sheets were produced in a doctor blade method therefrom. A silver paste was formed as an internal electrode pattern on the dielectric ceramic green sheets in a screen printing method, followed by bonding by pressure after lamination. Then a filter elements assembly was produced by cutting into pieces, and baking after removing the binder by heating. After applied with a silver paste, the external electrode formation area of the capacitor elements assembly was baked for forming a first external electrode having a thickness of 20 μ m. Then the adhering strength between the external electrode and the filter elements assembly was measured in the method the same as the first example to obtain the results the same as the first example.

The same effects were further obtained in a production method using PbTiO_3 - PbZrO_3 containing dielectric calcinated powders.

What is claimed is:

1. A production method of electronic components comprising a process of preparing an electronic component elements assembly having an external electrode formation area, a process of forming a first external electrode on the external electrode formation area of the electronic component elements assembly, and a process of forming a second external electrode on the first external electrode with a wet plating method using a plating liquid having dissolved oxygen eliminated.

2. The production method of electronic components according to claim 1, wherein an electroplating method is used as the wet plating method.

3. The production method of electronic components according to claim 1, wherein an electroless plating method is used as the wet plating method.

4. The production method of electronic components according to claim 1, wherein a residual oxygen concentration in the plating liquid after eliminating the dissolved oxygen is 7.0 mg/l or less.

5. The production method of electronic components according to claim 1, wherein dissolved oxygen in a plating liquid is eliminated by adding at least one selected from the group consisting of hydrazine, triethanol amine and sulfite



to the plating liquid.

6. The production method of electronic components according to claim 1 or 5, wherein dissolved oxygen is eliminated by aerating an inert gas in a plating liquid.

7. The production method of electronic components according to claim 1, wherein electronic components comprise ceramic electronic components containing an oxide of at least one selected from the group consisting of titanium, bismuth, lead, zirconia, calcium and niobium.

