

DESCRIPTION

SOLID ELECTROLYTIC CAPACITOR MANUFACTURING APPARATUS,
SOLID ELECTROLYTIC CAPACITOR MANUFACTURING METHOD AND
5 SOLID ELECTROLYTIC CAPACITOR

TECHNICAL FIELD

The present invention relates to an apparatus
for manufacturing solid electrolytic capacitors which
10 uses conductive polymer for solid electrolyte.
Describing more specifically, the manufacturing
apparatus can provide superior solid electrolyte
through electrolytic polymerization process. The
present invention further relates to a solid
15 electrolytic capacitor manufacturing method and a
solid electrolytic capacitor.

BACKGROUND ART

Reflecting the recent tend of using higher
20 frequency waves for electronic apparatus, capacitors
used in the apparatus are requested to exhibit lower
impedance values in the high frequency region. There
have been a number of proposals and studies being made
for implementing the low impedance by employing a
25 conductive polymer of high conductivity formed through
an electrolytic polymerization for the solid
electrolyte.

FIG. 16 is a cross sectional front view of a
conventional apparatus for manufacturing solid

electrolytic capacitors in which a layer of solid electrolyte is formed by electrolytic polymerization. FIG. 17 is a cross sectional side view of the apparatus of FIG. 16, sectioned along plane B-B. As shown in FIG. 16 and 17, polymerization tank 20 has a plurality of separation 21 disposed along transfer line at the same interval. As the result, there is a plurality of independent bath lanes stretching in the direction perpendicular to the line of transfer in polymerization tank 20. Each of the bath lanes is filled with polymerization solution 22 which is composed of a monomer of polymer for the skeleton of solid electrolyte and a dopant for providing conductivity. Belt-shaped aluminum foil anode body 23 is supplied continuously from a supply section (not shown), which is guided to each of the plurality of independent bath lanes formed separated by separation 21 in polymerization tank 20. Anode body 23 is bonded at the upper surface with anode electrode 24, which is a nickel tape. There are an adhesive agent provided between anode electrode 24 and anode body 23.

Front power supply roller 25a and rear power supply roller 25b are provided for delivering electric power of power supply 26 to anode electrode 24. Front power supply roller 25a is disposed at a location before anode body 23 is immersed in polymerization solution 22, while rear power supply roller 25b is disposed at a location after anode body 23 was pulled up out of the polymerization solution 22.

Rear power supply roller 25b is provided for making the power supply stable. This means that it is not an essential item, or the rear power supply roller 25b can be eliminated in designing a manufacturing apparatus. Front power supply roller 25a is to press and bond anode electrode 24 onto anode body 23, besides supplying the power.

Cathode electrode 27, or the counterpart of anode electrode 24, is shaped like a letter "U" upside-down in cross section. The cathode electrode 27 is disposed over separation 21 in each of the adjacent independent bath lanes, with its side edges bent slightly outward so that they are directed towards anode electrode 24 which has been bonded on anode body 23. The plurality of cathode electrodes 27 having the above-described structure are connected together using a flat conductive bar 28 to be coupled with power supply 26.

The independent bath lanes formed separated by means of separation 21 are provided respectively with spacer 29 for preventing evaporation of polymerization solution 22 kept in the bath lane.

The conventional solid electrolytic capacitor manufacturing apparatus further includes polymerization solution supply section 30, polymerization solution discharge section 31, entrance transfer roller 32 and exit transfer roller 33.

On the above-described conventional manufacturing apparatus, anode body 23 bonded at the

upper surface with anode electrode 24 is taken in from the polymerization solution supply section 30 side, and transferred via entrance transfer roller 32 to be immersed into polymerization solution 22 kept in the
5 respective bath lanes of polymerization tank 20. In the mean time, anode electrode 24 and cathode electrode 27 are applied with a certain voltage from power supply 26 to have a solid electrolytic layer composed of conductive polymer formed on the surface
10 of anode body 23 with anode electrode 24 as the starting point of electrolytic polymerization. It goes out of the solution at the polymerization solution discharge section 31 side via exit transfer roller 33.

15 Patent Document 1 is an example of the known prior art technology information.

In the conventional solid electrolytic capacitor manufacturing apparatus described in the above, however, there exists a subtle difference in the
20 potential even among cathode electrodes 27 of respective independent bath lanes due to voltage used for controlling electrolytic polymerization, voltage fluctuation, etc. Furthermore, polymerization solution 22 reaches up to the upper part of separation
25 21 which brings about mutual contact of cathode electrodes 27 with polymerization solution 22. As the result, conductive polymer is generated and sticks on cathode electrode 27. Starting from the conductive polymer thus generated, it spreads onto the surface of

separation 21, even to the inner wall surface of polymerization tank 20. Consequently, an effective area of cathode electrode 27 changes, which ill-affects homogeneous forming of a solid electrolytic
5 layer over anode body 23.

Still further, since polymerization tank 20 has been split by separations 21 into narrow independent bath lanes filled with polymerization solution 22, the solution circulating in narrow lane easily overflows
10 if circulation volume is increased. So, it may be difficult to increase the flow volume of polymerization solution 22. Therefore, in the course of a continuous operation of electrolytic polymerization, composition of polymerization solution
15 22 gradually shifts, which makes it difficult to provide a solid electrolytic layer homogeneously.

A belt-shaped nickel tape for anode electrode 24 which is bonded on the upper surface of anode body 23 for starting the electrolytic polymerization is an
20 expensive material; so, it is normally used repeatedly. Anode electrode 24 pulled out of polymerization solution 22 after undergoing the electrolytic polymerization process is covered with a film of solid electrolyte composed of conductive polymer generated
25 as the result of electrolytic polymerization, which film is sticking firm on the surface of anode electrode 24. Since the film is non-conductive, it is insulated and the conductivity of nickel tape anode electrode 24 is not ensured. Therefore, it is

required to provide an additional step for removing the solid electrolytic film by destroying the film with a rotary brush, metal roller, or the like machines.

5 Inventors of the present invention proposed following technology for reducing the manufacturing cost, which technology is disclosed in Patent Document 2, Japanese Patent Unexamined Publication No.2006-173303. The proposed technology uses an anode
10 electrode (anode electrode 24a) which is made of an aluminum foil or an aluminum foil-clad material used as the substrate and provided at the surface opposite to the bonding surface with a conductive thin layer formed by at least nickel, carbon or stainless steel
15 in place of anode electrode 24. It was expected that the proposed electrode would lead to a substantial cost reduction. When removing the solid electrolyte film composed of conductive polymer generated on the surface through electrolytic polymerization by
20 mechanically breaking it, however, even anode electrode 24a itself was also broken because the substrate is not strong enough. Thus, it was shown that removal of the solid electrolytic film was not an easy task.

25 Then, another trial was experimentally introduced to rear power supply roller 25b of the conventional solid electrolytic capacitor manufacturing apparatus shown in FIG. 16. The trial is as shown in FIG. 18; the rear power supply roller

25b is provided with a plurality of power supply pin 25c at regular interval, which pin having a conical-shape tip end. Power supply pin 25c is designed to pierce into anode electrode 24a; thereby, breaking
5 part of the solid electrolyte film and establishing electrical connection with anode electrode 24a as shown in FIG. 19. In some cases, however, the solid electrolytic film is pushed-in by the intruding power supply pin 25c into aluminum foil which is forming the
10 substrate of anode electrode 24a, as shown in FIG. 19. Then, the solid electrolytic film intervenes between power supply pin 25c and the aluminum foil, disturbing electrical conduction. This caused an instable power supply as shown in FIG. 20, a supply current waveform
15 chart. Instable power supply ill-affects stable performing of electrolytic polymerization process.

The present invention aims to solve these conventional problems which remain unsolved, and offers a solid electrolytic capacitor manufacturing
20 apparatus in which the solid electrolytic film formed on the surface of anode electrode during electrolytic polymerization process can be removed easily even when an anode electrode made of inexpensive material is used thereon. Thus the present solid electrolytic
25 capacitor manufacturing apparatus performs a high quality electrolytic polymerization on the basis of well-stabilized power supply.

Publication No.2000-200734

Patent Document 2

Japanese Patent Unexamined

Publication No.2006-173303

5 SUMMARY OF THE INVENTION

The present invention includes a top-open polymerization tank filled with a polymerization solution, an anode body supply section for transferring anode body formed of a belt-shaped electrode foil into the polymerization solution, an anode electrode bonding section for bonding belt-shaped anode electrode on the upper surface of anode body before the anode body is put into polymerization solution, an oblong cathode electrode stretching along the direction of transfer in polymerization solution of anode body bonded with anode electrode arranged on the both sides in the width direction of anode body in a noncontact status with respect to anode body and to polymerization tank, and a power supply for applying a voltage between the anode electrode and the cathode electrode. Electrolytic polymerization is performed while anode body is transferred in the polymerization solution with a voltage being applied between the anode electrode and the cathode electrode, and a solid electrolytic layer composed of conductive polymer is formed on the surface of anode body.

The present invention uses an aluminum foil or an aluminum foil clad material as substrate for the belt-shaped anode electrode, which is to be bonded on

the upper surface of anode body, which anode electrode being provided with a conductive thin layer formed by at least one material selected from the group of nickel, carbon and stainless steel at the surface opposite to bonding surface. While the anode body is transferred in the polymerization solution, a certain voltage is applied between anode electrode and cathode electrode. A solid electrolytic layer which is composed of conductive polymer is formed on the surface by electrolytic polymerization.

As described in the above, a solid electrolytic capacitor manufacturing apparatus in the present invention has a cathode electrode for forming a solid electrolytic layer composed of conductive polymer by electrolytic polymerization, which cathode electrode being disposed on the both sides in the width direction of the anode body bonded with anode electrode in a noncontact status with respect to the anode body and to the polymerization tank. In the above setup, there is nothing around the cathode electrode that would cause an obstacle to circulation of the polymerization solution. So, a smooth circulation is assured, and circulating volume of polymerization solution can be increased and polymerization current raised. This not only improves the manufacturing productivity, but it substantially reduces the conductive polymer sticking to the inner wall surface of polymerization tank and a resultant change in the effective area of cathode electrode.

Thus, it enables to provide solid electrolytic layer composed of conductive polymer homogeneously on anode body. Furthermore, a distance between anode body and cathode electrode can be kept constant even if anode
5 body sagged. In this way, a homogeneous solid electrolytic layer can be provided on stable basis.

A power supply roller placed after anode body was pulled up out of the polymerization solution is provided on the circumferential surface with a
10 plurality of power supply pin whose tip end has been cut oblique. In this structure, the power supply pin having an obliquely-cut tip end pierces through anode electrode which has just undergone electrolytic polymerizing process and covered at the surface with a
15 solid electrolytic film. Thereby, the solid electrolytic film is broken, and the incised face of anode electrode's substrate becomes exposed and the electrical conductivity is ensured. In this way, the power supply can be made in a stable manner and the
20 electrolytic polymerization performed at high quality level.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional front view of a
25 solid electrolytic capacitor manufacturing apparatus in accordance with a first exemplary embodiment of the present invention.

FIG. 2 shows the cross sectional side view of the solid electrolytic capacitor manufacturing

apparatus.

FIG. 3 is a cross sectional view showing rear power supply roller of the solid electrolytic capacitor manufacturing apparatus.

5 FIG. 4 is a cross sectional view showing a power supply pin of the rear power supply roller.

FIG. 5 is a cross sectional view showing the structure of an anode electrode used on the solid electrolytic capacitor manufacturing apparatus.

10 FIG. 6 is a perspective view showing a dam formed in a distribution tank of the solid electrolytic capacitor manufacturing apparatus.

FIG. 7 shows a plan view of an anode body of the solid electrolytic capacitor manufactured by the solid electrolytic capacitor manufacturing apparatus.

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FIG. 8 is a current waveform chart showing a state of power supply from power supply roller in the solid electrolytic capacitor manufacturing apparatus.

FIG. 9 is a cross sectional view showing the vicinity of rear power supply roller of a solid electrolytic capacitor manufacturing apparatus in accordance with a second exemplary embodiment.

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FIG. 10 is a current waveform chart showing a state of power supply from power supply roller in the solid electrolytic capacitor manufacturing apparatus.

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FIG. 11 is a cross sectional view showing the vicinity of other rear power supply roller in accordance with the second exemplary embodiment.

FIG. 12 is a current waveform chart showing a

state of power supply from power supply roller of the solid electrolytic capacitor manufacturing apparatus.

FIG. 13 is a cross sectional view showing the vicinity of rear power supply roller in accordance with a third exemplary embodiment of the present invention.

FIG. 14 shows an auxiliary power supply roller of FIG. 13, as viewed from the bottom.

FIG. 15 is a current waveform chart showing a state of power supply from power supply roller of the solid electrolytic capacitor manufacturing apparatus.

FIG. 16 is a cross sectional front view of a conventional solid electrolytic capacitor manufacturing apparatus.

FIG. 17 is the cross sectional side view of a conventional solid electrolytic capacitor manufacturing apparatus.

FIG. 18 is a cross sectional view showing rear power supply roller provided with power supply pins, in the solid electrolytic capacitor manufacturing apparatus.

FIG. 19 is a cross sectional view showing a power supply pin disposed on rear power supply roller described in the conventional solid electrolytic capacitor manufacturing apparatus.

FIG. 20 is a current waveform chart showing a state of power supply from power supply roller described in FIG. 18.

Reference marks in the drawings

	1	Anode Body
	1a	Rectangular Section
	1b	Cathode Forming Section
5	1c	Anode Pull-out Section
	2	Insulating Tape
	3	Anode Electrode
	3a	Substrate
	3b	First Substrate
10	3c	Second Substrate
	3d	Conductive Thin Layer
	3e	Adhesive Layer
	3f	Protection Tape
	4	Front Power Supply Roller
15	5	Rear Power Supply Roller
	5a	Power Supply Pin
	6	Polymerization Tank
	6a, 11a, 12a	Dam
	7	Polymerization Solution
20	8	Cathode Electrode
	9	Conductive Plate
	10	Conductive Plate Stand
	11	Supply Tank
	12	Distribution Tank
25	12b	Slit
	13	Discharge Tank
	14	Power Supply
	15	Entrance Transfer Roller
	16	Exit Transfer Roller

- 17 Cover Board
- 18a First Auxiliary Power Supply Plate
- 18b Second Auxiliary Power Supply Plate
- 18c Third Auxiliary Power Supply Plate
- 5 19 Auxiliary Power Supply Roller

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIRST EXEMPLARY EMBODIMENT

10 The present invention is described below using its first exemplary embodiment.

FIG. 1 is a cross sectional front view of a solid electrolytic capacitor manufacturing apparatus in accordance with first exemplary embodiment, used to show the structure; FIG. 2 shows cross sectional side view of the manufacturing apparatus shown in FIG. 1, sectioned along the A-A plane; FIG. 3 is a cross sectional view of rear power supply roller of the manufacturing apparatus; FIG. 4 shows a cross sectional view of a power supply pin of the rear power supply roller; FIG. 5 is a cross sectional view which shows the structure of an anode electrode, used on the above manufacturing apparatus; FIG. 6 is a perspective view which shows a dam provided in distribution tank of the above manufacturing apparatus; FIG. 7 is a plan view of an anode body of the solid electrolytic capacitor manufactured by the solid electrolytic capacitor manufacturing apparatus.

As shown in FIG. 1 through FIG. 7, anode body 1

used on a solid electrolytic capacitor manufacturing apparatus in accordance with the first embodiment is made with a 0.1mm thick belt-shaped aluminum foil; the surface is roughened by an electrochemical treatment and provided with aluminum oxide dielectric film, and then punched to a certain specific form as shown in FIG. 7. Provided at the both ends are rectangular section 1a of a 3mm x 4mm size. Insulating tape 2 which is made with a metal material such as stainless steel, nickel, etc. applied with an adhesive resin is affixed continuously along the length direction on rectangular section 1a; thereby, it is divided into cathode forming section 1b on which a solid electrolytic layer composed of conductive polymer will be formed (to be described later) and anode pull-out section 1c. On the dielectric oxide film formed at cathode forming section 1b, a conductive layer of manganese dioxide has been formed by first impregnating with water solution of manganese nitrate and then pyrolyzing it.

A belt-shaped anode electrode 3 which is wound in a reel (not shown) is supplied from a supply unit (not shown) to be overlaid on belt-shaped anode body 1 which also is wound in a reel and supplied from an anode body supply unit (not shown). Anode electrode 3 is pressed by front power supply roller 4, which is provided for supplying power from power supply 14 (to be described later) to anode electrode 3, onto anode body 1 to be bonded thereon. Namely, front power

supply roller 4 works as anode electrode bonding unit for bonding anode electrode 3 onto anode body 1, at the same time it performs also the function of applying a voltage to anode electrode 3.

5 A state of anode body 1 after the bonding is as shown in FIG. 7; where, anode electrode 3 is bonded covering anode pull-out section 1c and part of insulating tape 2. Anode body is transferred in this state into polymerization tank 6 (to be described
10 later).

As shown in detail in FIG. 5, anode electrode 3 includes first substrate 3b of a $20\mu\text{m}$ thick aluminum foil, Al purity higher than 95.70%, aluminum alloy JIS No.5052, and second substrate 3c of a $5\mu\text{m}$ thick
15 aluminum foil, Al purity higher than 99.85%, aluminum alloy JIS No.1085. Second substrate 3c is provided at the both surfaces of first substrate 3b; these substrates are rolled to a 180mm wide $30\mu\text{m}$ thick for providing substrate 3a. Substrate 3a is provided at
20 one of the surfaces with a $0.1\mu\text{m}$ thick conductive nickel layer 3d formed by vacuum deposition, while on the other surface with adhesive layer 3e. Protection tape 3f is disposed covering adhesive layer 3e. The integrated substrate is cut into strips of a 7.5mm
25 width using a slitting machine to be ready for use.

Anode electrode 3 thus provided is formed using an inexpensive aluminum foil clad material. So, it exhibits superior characteristics in the electric resistance, at the same time enables to reduce the

manufacturing cost substantially. Despite a low cost, the aluminum clad material offers a sufficiently high mechanical strength and the power supply function does not deteriorate in polymerization solution. Thus, it demonstrates excellent characteristics comparable to those of conventional anode electrode which is made of a nickel tape.

Front power supply roller 4 is for applying a voltage on anode electrode 3, it at the same time presses anode electrode 3 onto anode body 1 for bonding. Namely, the front power supply roller 4 works also as an anode electrode bonding unit. Front power supply roller 4 is disposed at a place before anode body 1 bonded with anode electrode 3 is immersed in electrolytic solution, which is to be described later.

Rear power supply roller 5, too, is for applying a voltage on anode electrode 3. The rear power supply roller 5 locates at a place after anode body 1 underwent the electrolytic polymerization and pulled up from the electrolytic solution. Anode electrode 3, which has been bonded with anode body 1, is pulled up together from polymerization solution 7 by exit transfer roller 16 (described later). Rear power supply roller 5 starts peeling anode electrode 3 off anode body 1. Rear power supply roller 5 is provided at the circumferential wall surface with a plurality of power supply pin 5a whose tip ends are cut obliquely. The pins are orientated so that their

obliquely-cut faces are directed towards the upstream of anode body transfer, and a push up amount of the pins above the surface of rear power supply roller 5 is made to be greater than thickness of anode electrode 3. The angle of oblique cut in the present embodiment is 30 degrees, viz. an acute angle.

Polymerization tank 6, which is oblong shaped and open at the top, is filled with polymerization solution 7 for electrolytic polymerization. In the present embodiment, water solution of pyrrolemonomer 0.2mol/liter, alkyl naphthalenesulfonate 0.1mol/liter is used for polymerization solution 7.

Cathode electrode 8 is made of a stainless steel, platinum or the like metal, or a conductive carbon material, formed in an oblong shape in line with direction of anode body 1 bonded with anode electrode 3 being transferred in polymerization solution 7. The cathode electrode 8 is arranged on the both sides in the width direction of anode body 1 in the polymerization solution 7 in a noncontact status with respect to anode body 1 and to polymerization tank 6.

In the present exemplary embodiment, a plurality of anode body 1 is provided at a regular interval in the direction that is perpendicular to the transfer direction, and cathode electrodes 8 on the both sides in the width direction of respective anode bodies 1 in the same orientation (ref. FIG. 2).

Each of the plurality of cathode electrode 8 is connected at its one end with conductive plate 9,

which plate is supported by conductive plate stand 10. The conductive plate stand 10 stands alone being independent of polymerization tank 6 so as there is no direct contact with the polymerization tank 6.

5 Supply tank 11 is provided at the upstream side of polymerization tank 6, and distribution tank 12 is connected to supply tank 11. Supply tank 11 is normally replenished with polymerization solution 7 to the full. Overflowing solution goes over dam 11a,
10 which is provided between supply tank 11 and distribution tank 12, to be kept in distribution tank 12. After distribution tank 12 is filled to the full, polymerization solution 7 floods into polymerization tank 6 beyond dam 12a locating between distribution
15 tank 12 and polymerization tank 6.

 Dam 12a is provided at the top edge with a plurality of slit 12b at a regular interval, the slit 12b is locating so as it corresponds to the center of space between cathode electrodes 8 in polymerization
20 tank 6. So, the overflowing polymerization solution 7 coming out of slit 12b flows towards the center between cathode electrodes 8.

 Discharge tank 13 is provided at the downstream end of polymerization tank 6. Polymerization solution
25 7 overflowing from dam 6a of polymerization tank 6 flows into discharge tank 13, which solution is recycled via circulation tank (not shown) to supply tank 11.

 Power supply 14 applies a certain voltage for

electrolytic polymerization between front power supply roller 4/rear power supply roller 5 and conductive plate 9 which is coupled with the plurality of cathode electrodes 8.

5 A solid electrolytic capacitor manufacturing apparatus in the present embodiment is equipped with entrance transfer roller 15 for guiding anode body 1 bonded with polymerization electrode 3 into polymerization solution 7, and exit transfer roller 16
10 which pulls up anode body 1, after finishing electrolytic polymerization, from the polymerization solution 7.

 Rectangular cover board 17 made of polyvinyl chloride is provided floating on polymerization
15 solution 7 at each of the spaces between cathode electrodes 8. The floating board is aimed to prevent the polymerization solution 7 from evaporating and to maintain the surface of solution stabilized. In order to keep cover board 17 out of having contact with
20 cathode electrode 8 at the surface of solution, the cover board 17 is loosely fastened to conductive plate 9 with a rope made of an insulating resin material (not shown).

 Now in the following, the operation of solid
25 electrolytic capacitor manufacturing apparatus built in accordance with the present exemplary embodiment is described.

 Anode body 1 in the form of belt-shaped aluminum foil and anode electrode 3 made of an aluminum clad

material in belt form are delivered from respective supply units (not shown) to be overlaid together. Anode electrode 3 is bonded on anode body 1 at front power supply roller 4, and then entrance transfer roller 15 transfers the bonded belt to be immersed into polymerization solution 7 which is kept in polymerization tank 6.

While anode body 1 is traveling in polymerization solution 7, a certain voltage of power supply 14 is applied between anode electrode 3 and respective cathode electrodes 8, via front power supply roller 4, rear power supply roller 5 and conductive plate 9. Electrolytic polymerization is started with anode electrode 3 as the starting point of reaction. In approximately 15 minutes, a desired solid electrolytic layer composed of conductive polypyrrole polymer is formed covering entirely the both surfaces of anode body 1's cathode forming section 1b.

Anode body 1 bearing the solid electrolytic layer is pulled up from polymerization solution 7 via exit transfer roller 16. And then at rear power supply roller 5, anode electrode 3 bonded to anode body 1 is peeled off. Anode body 1 alone is sent to the next step which is not shown here.

When anode electrode 3 proceeds through rear power supply roller 5, a plurality of power supply pin 5a provided on the circumferential surface of rear power supply roller 5 pierces into anode electrode 3,

and solid electrolytic film is broken as illustrated in FIG. 4 allowing power supply pin 5a to have electrical conduction with substrate 3a of anode electrode 3.

5 Power supply pin 5a is obliquely cut at the tip end, and the cut face is orientated so as to be facing towards the upstream direction of anode body transfer. An amount of push up with power supply pin 5a above the surface of rear power supply roller 5 is set to be
10 greater than a thickness of anode electrode 3. In this arrangement, solid electrolytic film formed on anode electrode 3 is pushed into substrate 3a with the surface having been contacted by the oblique cut-face of power supply pin 5a; consequently, power supply pin
15 5a's tip end gets contact at its upright portion with substrate 3a. Thus, a reliable electrical connection can be established as shown in FIG. 8, a chart of supply current waveform. The angle of oblique cut at tip end of power supply pin 5a is set at 30 degrees,
20 an acute angle, in the present exemplary embodiment. However, it is to be understood that it is not the intension of the present invention to limit the scope to the above-described cut angle.

As described in the above, a solid electrolytic
25 capacitor manufacturing apparatus in accordance with the first embodiment includes a plurality of power supply pins whose tip ends have been cut oblique, the power supply pin being planted on the circumferential wall surface of power supply roller, for example, rear

power supply roller 5, which is disposed at a location after pull-up from polymerization solution. An anode electrode after the electrolytic polymerization, which bears solid electrolytic film formed on the surface, is pierced by the power supply pin which has an oblique-cut tip end. Thereby, the solid electrolytic film is broken and the substrate is disclosed at its incised face in favor of establishing an electrical conduction. Consequently, it can perform a stabilized power supply and provide a high quality level electrolytic polymerization even when an anode electrode made of low cost material is used.

SECOND EXEMPLARY EMBODIMENT

A solid electrolytic capacitor manufacturing apparatus in accordance with a second exemplary embodiment is different from that of the first exemplary embodiment in that an auxiliary power supply plate is provided at the downstream of rear power supply roller. For the rest, structure remains identical to that of the first embodiment. So, those identical portions are designated using identical symbols respectively, and detailed description on such is eliminated. Only the point of difference will be described in the following referring to the drawings.

FIG. 9 is a cross sectional view which shows the vicinity of rear power supply roller of a solid electrolytic capacitor manufacturing apparatus in accordance with the second embodiment. Referring to

FIG. 9, first auxiliary power supply plate 18a is provided at the downstream of rear power supply roller 5. First auxiliary power supply plate 18a applies a certain voltage to anode electrode 3 from its bonded surface (adhesive layer 3e). Although not shown in the drawing, first auxiliary power supply plate 18a is connected with power supply 14.

In a solid electrolytic capacitor manufacturing apparatus in accordance with the present second embodiment, when anode electrode 3 goes through rear power supply roller 5 it is pierced by a plurality of power supply pin 5a planted on the circumferential wall surface of rear power supply roller 5, and the solid electrolytic film is broken, as already described in the first embodiment referring to FIG. 4. Further to the advantage provided in the first embodiment, first auxiliary power supply plate 18a makes contact with substrate 3a at incised face 3g which became exposed as the result of piercing by power supply pin 5a, making the electrical connection more reliable. Thereby, the power supply becomes more stable as shown in FIG. 10, a power supply waveform chart. Thus the quality of electrolytic polymerization can be further improved.

FIG. 11 is a cross sectional view which shows the vicinity of rear power supply roller in other example of the second embodiment. Here, second auxiliary power supply plate 18b is provided in addition at the downstream of first auxiliary power

supply plate 18a described in FIG. 9. Thereby, the stability in the power supply is further improved as shown in FIG. 12, a power supply waveform chart.

5 **THIRD EXEMPLARY EMBODIMENT**

Now in the following, the present invention is described using a third exemplary embodiment.

An auxiliary power supply plate and an auxiliary power supply roller are provided in addition at the downstream of rear power supply roller of solid electrolytic capacitor manufacturing apparatus in the first embodiment. The auxiliary power supply roller accompanies an auxiliary power supply plate which is having contact with the roller. For the rest, structure remains identical to that of the first embodiment. So, the identical portions are designated respectively using identical symbols, and detailed description of which is eliminated. Only the point of difference is described referring to the drawings.

FIG. 13 is a cross sectional view which shows the vicinity of rear power supply roller of a solid electrolytic capacitor manufacturing apparatus in accordance with a third exemplary embodiment. FIG. 14 is a bottom view of auxiliary power supply roller of FIG. 13, as seen from the underneath.

Reference is made to FIG. 13 and FIG. 14, first auxiliary power supply plate 18a is provided at the downstream of rear power supply roller 5, and auxiliary power supply roller 19 consecutively at the

downstream of first auxiliary power supply plate 18a. Auxiliary power supply roller 19 includes third auxiliary power supply plate 18c, which plate is disposed so as it makes contact with the bottom part of auxiliary power supply roller 19 at a region of the roller other than that where anode electrode 3 have contact to.

First auxiliary power supply plate 18a and auxiliary power supply roller 19 are provided for applying a certain voltage to anode electrode 3 from the bonding surface (adhesive layer 3e). Although not shown in the drawing, first auxiliary power supply plate 18a, auxiliary power supply roller 19 and second auxiliary power supply plate 18b are coupled with power supply 14.

As shown in FIG. 14, a solid electrolytic capacitor manufacturing apparatus in accordance with a third embodiment is provided with third auxiliary power supply plate 18c which is disposed so as it makes contact with auxiliary power supply roller 19 at a region of the roller other than that where anode electrode 3 makes contact to. Therefore, there is an open space on the surface of auxiliary power supply roller 19 at the side opposite to that where anode electrode 3 has contact.

During the operation, there can be some cases where fragments of adhesive layer 3e, which were disclosed accompanied by incised face 3g of substrate 3a as the result of thrusting by power supply pin 5a

through anode electrode 3, stick on first auxiliary power supply plate 18a and auxiliary power supply roller 19. Even if these contaminants heaped up and aged to deteriorate an electrical connection, they can
5 be easily removed from the circumferential surface using a wooden piece or with a solvent, etc. taking advantage of the open space. The contaminant removing operation can be carried out without stopping a manufacturing operation. Therefore, the contaminant
10 removing can be done as a routine. Thus a solid electrolytic capacitor manufacturing apparatus in accordance with the third embodiment is superior in the manufacturing productivity to those of the first and second embodiments. Furthermore, as FIG. 15, a
15 power supply waveform chart, indicates it offers stable power supply for implementing a high quality electrolytic polymerization.

INDUSTRIAL APPLICABILITY

20 A solid electrolytic capacitor manufacturing apparatus in the present invention can provide a stable power supply for electrolytic polymerization, even when an anode electrode made of low cost material is used on the manufacturing apparatus. This means
25 that it can offer high-quality solid electrolytic layers on stable basis. The present manufacturing apparatus would be especially advantageous when introduced in the production of solid electrolytic capacitors to be used for such applications where the

lower impedance in high frequency region is requested.

CLAIMS

1. A solid electrolytic capacitor manufacturing apparatus comprising:

5 a top-open polymerization tank;

an anode body supply section for transferring an anode body of belt-shaped electrode foil into polymerization solution kept in a polymerization tank;

10 an anode electrode bonding section for bonding belt-shaped anode electrode on an upper surface of anode body prior to immersion in the polymerization solution;

a cathode electrode arranged at both sides in a width direction of the anode body bonded with the anode electrode and transferred in the polymerization solution in a noncontact status with respect to the anode body and to the polymerization tank; and

15 a power supply for applying a voltage between the anode electrode and the cathode electrode, wherein,

20 a solid electrolytic layer composed of conductive polymer is formed on the surface of anode body by electrolytic polymerization while the anode body is transferred in the polymerization solution with a voltage being applied between the anode electrode and the cathode electrode.

2. The solid electrolytic capacitor manufacturing apparatus of claim 1, wherein the belt-shaped anode electrode to be bonded on the upper surface of the

anode body used thereon is formed of an aluminum foil or an aluminum foil clad material as substrate, and a conductive thin layer of at least one material selected from the group of nickel, carbon and stainless steel is provided at a surface opposite to a bonding surface.

3. The solid electrolytic capacitor manufacturing apparatus of claim 1, further comprising:

10 a front power supply roller disposed at a location before the anode body is immersed in the polymerization solution for applying a voltage to the anode electrode from a side of the conductive thin layer; and

15 a rear power supply roller disposed after the anode body has been pulled up out of the polymerization solution for applying a voltage to the anode electrode from the side of the conductive thin layer, wherein,

20 a plurality of power supply pins, whose tip ends are cut obliquely, is provided at a circumferential surface of the rear power supply roller.

4. The solid electrolytic capacitor manufacturing apparatus of claim 3, wherein

25 the power supply pins are orientated so that their obliquely-cut faces are directed towards an upstream of transfer of the anode body, and

 a push-up amount of the power supply pins over a

surface of the rear power supply roller is greater than a thickness of the anode electrode.

5. The solid electrolytic capacitor manufacturing apparatus of claim 3, wherein

a first auxiliary power supply plate is provided at a downstream of the rear power supply roller for applying a voltage to the anode electrode from the side of the bonding surface.

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6. The solid electrolytic capacitor manufacturing apparatus of claim 5, wherein

a second auxiliary power supply plate is provided at a downstream of the first auxiliary power supply plate for applying a voltage from the side of the bonding surface.

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7. The solid electrolytic capacitor manufacturing apparatus of claim 5, wherein

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an auxiliary power supply roller is provided at a downstream of the first auxiliary power supply plate for applying a voltage from the side of the bonding surface, and

a third auxiliary power supply plate is disposed so as to contact with auxiliary power supply roller at a place other than a place where the anode electrode makes contact to the auxiliary power supply roller.

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8. A solid electrolytic capacitor manufacturing

method performed using a solid electrolytic capacitor manufacturing apparatus, the solid electrolytic capacitor manufacturing apparatus including:

a top-open polymerization tank;

5 an anode body supply section for transferring an anode body of belt-shaped electrode foil into polymerization solution kept in a polymerization tank;

an anode electrode bonding section for bonding belt-shaped anode electrode on an upper surface of anode body prior to immersion in the polymerization solution;

a cathode electrode arranged at both sides in a width direction of the anode body bonded with the anode electrode and transferred in the polymerization solution in a noncontact status with respect to the anode body and to the polymerization tank; and

a power supply for applying a voltage between the anode electrode and the cathode electrode, the manufacturing method comprising:

20 forming a solid electrolytic layer composed of conductive polymer on the surface of anode body by electrolytic polymerization while the anode body is transferred in the polymerization solution with a voltage being applied between the anode electrode and the cathode electrode.

9. The solid electrolytic capacitor manufacturing method of claim 8, wherein

the method is performed using a solid

electrolytic capacitor manufacturing apparatus, the solid electrolytic capacitor manufacturing apparatus including:

5 a front power supply roller disposed at a location before the anode body is immersed in the polymerization solution for applying a voltage to the anode electrode from the conductive thin layer side;

a rear power supply roller disposed after the anode body has been pulled up out of the
10 polymerization solution for applying a voltage to the anode electrode from the conductive thin layer side;
and

a plurality of power supply pins, whose tip ends are cut obliquely, is provided at a
15 circumferential surface of the rear power supply roller; wherein,

a voltage is applied to the anode electrode from the power supply by breaking the solid electrolytic layer formed on the surface of the anode electrode
20 with the power supply pin.

10. A solid electrolytic capacitor manufactured in accordance with a manufacturing method recited in claim 8 or 9.