

SPECIFICATIONS

PTC ELEMENT AND METHOD OF MANUFACTURING THE SAME

[Technical Field]

5 The present invention relates to a PTC element
composed of a conductive composition material (hereinafter
referred to PTC composition material) showing positive
temperature properties, so-called PTC (Positive Temperature
Coefficient) properties that mean its resistance value
10 suddenly rises when a fixed temperature (hereinafter referred
to as a switching temperature) region is reached.

[Technical Background]

Up to now, being employed in electrical equipment and
15 electronic equipment as well as secondary batteries, PTC
elements are used as a protective element of electrical
circuits to prevent over-current that flows when an abnormal
state is happen in these apparatus.

In general, a PTC element is composed of a PTC
20 composition material obtained by blending and kneading
conductive powder with a crystalline polymer and of electrodes
formed on said PTC composition material, and shows sudden
increase in its resistance value when the switching
temperature is reached. That is, a PTC composition material
25 produces heat in accordance with joule heat (I^2R heat)
generated by resistance value R peculiar to the material and
electric current value I flowed in the element through the
above-mentioned electrodes. Like this, if relatively high

current flows in the PTC composition material, heat generation occurs to make its resistance value increase. In general, PTC elements are used as a sheet heat generation material using the generation of above-mentioned joule heat, an over-current protective element using increase in resistance value, and the like.

As former PTC elements, especially from the viewpoint of the method of forming their electrodes, for example, the following 3 elements are known.

First, an element in which the surface of a metal plate of stainless steel, or nickel and the like is agglutinated on the surface of a PTC composition material and the metal plate is used as electrodes.

Second, an element in which in order to improve the adhesion of such electrodes and a PTC composition material, the surface of a metal plate is further roughened physically or chemically and the roughened surface is agglutinated on the surface of a PTC composition material to make electrodes.

Third, an element in which a PTC composition material is directly metal plated to make electrodes.

However, in the first former example in which electrodes are made by agglutinated the surface of a metal plate on the surface of a PTC composition material, the contact resistance value between the PTC composition material and the electrode becomes high and good ohmic contact cannot be obtained. As a result, in the PTC composition material relating to this first former example, because resistance value becomes high at room temperature, it is difficult to use the PTC composition

material as an over-current protective element and the like.
In addition, because the adhesion between the PTC
composition material and the electrodes is insufficient,
resistance value increases greatly in cases where the PTC
5 element is repeatedly operated (turning on electricity).

Moreover, in the second former example in which the
surface of a metal plate roughened physically or chemically is
agglutinated on the surface of a PTC composition material to
make electrodes, the contact resistance value between the PTC
10 composition material and the electrode becomes lower than
that in the above-mentioned first former example and the
adhesion between the two also becomes better, but it is not yet
reached to obtain good ohmic contact. In association with
the second former example, it is also proposed to increase the
15 amount of conductive powder to be dispersed in a PTC
composition material up to 45 volume percent or more in order
to improve the stability of the PTC element against its
repeated operation as well as lowering its resistance value at
room temperature. However, also in this case, it is difficult
20 not only to lower the resistance value at room temperature to a
certain value or less but also to retard completely the increase
in the resistance value for every operation when operations
are repeated.

Furthermore, in the third former example in which a
25 PTC composition material is directly metal plated to make
electrodes, the adhesion between the PTC composition
material and the plated coat is not sufficient and the contact
resistance value between the two becomes high. And great

increase in resistance value due to repeated operation is also inevitable.

As a controversial point common in the first to third former examples, there is a problem that resistance values at
5 room temperature increase due to the deterioration of PTC composition materials themselves in cases where those PTC elements are repeatedly operated. As a cause for this problem, it is presumed that crystalline polymer components deteriorate due to heat shock for every operation when
10 operations are repeated.

On the other hand, since a PTC composition material is a complex material of an organic matter and an inorganic substance, there is also such a problem that the composition material is greatly affected by environmental humidity during
15 being stocked and used and the change of its resistance becomes to be great as the passage of time when switching operation is repeatedly carried out. In particular, in order to obtain an element having good conductivity in a PTC composition material using metallic conductive filler, it is
20 needed to fill up the conductive filler in large amount. But when a conductive filler of inorganic substance is filled in large amount, the resulting composition material is easily affected by environmental humidity during being stocked and used. And, as mentioned above, since the element itself
25 becomes to be apt to peel off from the electrodes as the passage of time when switching operation is repeatedly carried out, the composition material could not obtain sufficient reliability for the long time usage (repeated usage).

It is therefore the first object of the present invention to provide a PTC element that is excellent in stability to repeated operation and has sufficient adhesion with the PTC composition material and electrodes with low contact resistance value, and to provide its production method.

It is the second object of the present invention, in a PTC element and its production method to achieve the above-mentioned first object, to provide a PTC element that can effectively prevent the PTC element itself from peeling off from the electrodes due to the effect of environmental humidity and is good in stability and reproducibility to repeated usage and has a high reliability.

[Disclosure of the Invention]

In order to achieve the above-mentioned first object, in the PTC element and its production method of the present invention, conductive powder filler composed of at least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C is blended and kneaded with a crystalline polymer component by 35 to 60 volume percent to form a formed composition material, a conductive material is pressure sealed and buried so that the material is partly exposed from the surface of said formed composition material, and then electrodes are formed by plating on said surface of said formed composition material.

That is, according to an aspect of the present invention, a PTC element can be obtained, and the PTC element is characterized in that it has a formed composition material in which conductive powder filler is blended and kneaded with a

crystalline polymer component by 35 to 60 volume percent, a
conductive material pressure sealed and buried so that the
material is partly exposed from the surface of said formed
composition material, and electrodes formed by plating on said
5 surface of said formed composition material, and in that at
least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C is
used as said conductive powder filler.

Said conductive material is preferable to include Ni
powder, Al powder, Cu powder, Fe powder, Ag powder, or
10 graphite powder.

And, it is preferable to form a formed composition
material by blending and kneading said conductive powder
filler with a crystalline polymer component by 45 to 60 volume
percent.

15 Further, according to another aspect of the present
invention, it is possible to obtain a production method of a
PTC element that is characterized in that the method has a
process in which a formed composition material is obtained by
means of blending and kneading at least one out of TiC, WC,
20 W₂C, ZrC, VC, NbC, TaC, and Mo₂C with a crystalline polymer
component by 35 to 60 volume percent as a conductive powder
filler, a process in which after coated said formed composition
material with a conductive paste containing a conductive
powder, said conductive powder is treated by pressure sealing
25 to bury said conductive powder so that part of said conductive
powder is exposed from the surface of said formed composition
material, and a process in which said surface of said formed
composition material is plated to form electrodes.

It is preferable that Ni powder, Al powder, Cu powder, Fe powder, Ag powder, or graphite powder is used as said conductive powder.

And, it is preferable that said conductive powder filler is
5 blended and kneaded with a crystalline polymer component by 45 to 60 volume percent to form a formed composition material.

In order to achieve the above-mentioned second object, in the PTC element and its production method of the present
10 invention, conductive powder filler composed of at least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C is blended and kneaded with a crystalline polymer component by 35 to 60 volume percent to form a formed composition material, a conductive material is pressure sealed and buried so that the
15 material is partly exposed from the surface of said formed composition material, then electrodes are formed by plating on said surface of said formed composition material, moreover, a steam barrier layer is formed in the part other than said plated electrode of the PCT element.

20 That is, according to further another aspect of the present invention, it is possible to obtain a PTC element that is characterized in that the PTC element has a formed composition material in which a conductive powder filler using at least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C
25 is blended and kneaded with a crystalline polymer component by 35 to 60 volume percent, a conductive material which is pressure sealed and buried so that it is partly exposed from the surface of said formed composition material, electrodes

formed by plating on said surface of said formed composition material, and a steam barrier layer formed in the part other than said plated electrode.

It is preferable that said crystalline polymer component
5 is a polymer alloy in which at least one kind of thermoplastic polymer is mixed.

Moreover, according to a further different aspect of the present invention, it is possible to obtain a production method of a PTC element that is characterized in that the method has
10 a process in which a formed composition material is obtained by means of blending and kneading at least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C with a crystalline polymer component by 35 to 60 volume percent as a conductive powder filler, a process in which after coated said formed composition
15 material with a conductive paste containing a conductive powder, said conductive powder is treated by pressure sealing to bury said conductive powder so that part of said conductive powder is exposed from the surface of said formed composition material, a process in which said surface of said formed
20 composition material is plated to form electrodes, and a process in which a steam barrier treatment is carried out in the part other than said plated electrodes.

[Brief Description of the Drawings]

25 Fig. 1 is a sectional view showing the PTC element related to the first embodiment of the present invention;

Fig. 2 indicates drawings to explain the production method of the PTC element related to the first embodiment of

the present invention, they are sectional views showing (a) the formed composition material, (b) a state where a conductive material is pressure sealed and buried so that it is partly exposed from the surface of the formed composition material, and (c) a state where said formed composition material is plated to form electrodes, respectively;

Fig. 3 is a graphical representation showing the temperature - resistivity property in a PCT element in an example of the present invention;

Fig. 4 is a graphical representation showing resistivity properties after current of 10A (50V) is repeatedly impressed on the PTC element of the first example of the present invention and on the PTC elements of comparative examples;

Fig. 5 is a partial sectional view showing the PTC element related to the second embodiment of the present invention; and

Fig. 6 indicates drawings to explain the production method of the PTC element related to the second embodiment of the present invention, (a) is a sectional view of a formed composition material, (b) is a sectional view showing a state where the conductive material is pressure sealed and buried so that it is partly exposed from the surface of the formed composition material, (c) is a sectional view showing a state where the composition material is plated to form electrodes, (d) is a schematic view showing steam barrier treatment, (e) is a partial sectional view showing the PTC element after steam barrier treatment is performed, respectively.

[Preferred Embodiment for carrying out the Present Invention]

The present invention will be explained in more detail according to attached drawings.

At first, referring to Figs from 1 to 4, the PTC element
5 and its production method related to the first embodiment of the present invention is explained.

As shown in Fig. 1, PTC element 10 related to the first embodiment of the present invention has formed composition material 12 in which conductive powder filler (not shown in
10 the figure) was blended and kneaded with a crystalline polymer component by 35 to 60 volume percent, conductive material 13 pressure sealed and buried so that it is partly exposed from surface 12A of formed composition material 12, and electrodes 14A and 14B formed by means of plate
15 treatment on surface 12A of formed composition material 12. As conductive powder filler, one or two kinds or more out of TiC, WC, W_2C , ZrC, VC, NbC, TaC, and Mo_2C can be used. Still more, conductive material 13 is preferable to include Ni powder, Al powder, Cu powder, Fe powder, Ag powder, or
20 graphite powder.

In order to produce PTC element 10 in embodiments of the present invention, it is necessary to have at least a process in which as shown in Fig. 2 (a), at least one out of TiC, WC, W_2C , ZrC, VC, NbC, TaC, and Mo_2C is blended and kneaded
25 with a crystalline polymer component by 35 to 60 volume percent as a conductive powder filler to obtain formed composition material 12, a process in which after conductive paste containing conductive powder 13 is coated on surface

12A of formed composition material 12, pressure sealing treatment of conductive powder 13 is carried out and, as shown in Fig. 2 (b), conductive powder 13 is buried so that it is partly exposed from surface 12A of formed composition material, and
5 a process in which as shown in Fig. 2 (c), surface 12A of formed composition material 12 is plated to form (plated) electrodes 14A and 14B.

And, an example of the production methods of above-mentioned PTC element 10 will be explained more concretely.

10 At first, crystalline high-density polyethylene having softening point of about 130°C as a polymer component and conductive powder filler of 1 to 5 μ m in particle size were blended and kneaded on a roller mill heated about 140 to 200°C so that the content of the conductive powder was 35 to 60
15 volume percent, and kneaded polymer material was obtained. Further, for example, one or two kinds or more out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C can be used as conductive powder [See Fig. 2(a)] .

Next, after the above-mentioned kneaded high polymer
20 material was powdered, the powder was press molded to make a sheet and a sheet of kneaded polymer material was obtained as a result. Then, both sides of the kneaded polymer material were coated with conductive paste composed of Ni powder, polyvinylbutyral, and a solvent and dried at room
25 temperature for 5 hours or more to make a dried sheet. This dried sheet was pressed at temperatures of about 140 to 200°C for about 5 to 15 minutes to make Ni powder pressure sealed. As a result, a PTC composition material sheet, in which most

of Ni powder was buried in the sheet and part of the powder was exposed on the surface of the sheet, was obtained [See Fig. 2 (b)] .

After the PTC composition material sheet pressure sealed as mentioned above was defatted in succession, Ni electroless plating was carried out on the sheet to form electrodes [See Fig. 2(c)] .

A test piece of 1 cm² in area was punched out from the Ni plated sheet obtained as mentioned above and used as a sample for assay (hereinafter, this sample for assay is referred to as "the example"). Furthermore, as conductive powder buried in the sheet by pressure sealing, it is acceptable to use Al powder, Cu powder, Fe powder, Ag powder, or graphite powder, as well as Ni powder.

Then, to compare with the example, comparative sample 1 was prepared as in the following (hereinafter, this comparative sample is referred to as "comparative example 1")

In this comparative example 1, the same treatment as in above-mentioned example was carried out until the kneaded polymer material was sheeted. After that, metal plates were agglutinated on both sides of the kneaded material sheet by heat pressing at temperatures of about 140 to 200°C to form electrodes. And, a test piece of 1 cm² in area was punched out from this sheet and a PTC element was obtained (Comparative example 1).

Moreover, comparative sample 2 was prepared as in the following (hereinafter, this comparative sample is referred to

as "comparative example 2"). Also in this comparative example 2, the same treatment as in the above-mentioned example was carried out until kneaded polymer material was sheeted. After that, metal plates, their one side to be
5 contacted with the kneaded material sheet (one side of each metal plate) were roughened with electrolyte, were agglutinated on both sides of the kneaded material sheet by heat pressing at temperatures of about 140 to 200°C to form electrodes. And, a test piece of 1 cm² in area was punched out
10 from this sheet and a PTC element was obtained (comparative example 2).

Further, comparative sample 3 was prepared as in the following (hereinafter, this comparative sample is referred to as "comparative example 3"). Also in this comparative
15 example 3, the same treatment as in the above-mentioned example was carried out until kneaded polymer material was sheeted. After that, the kneaded material sheet was defatted and then Ni electroless plating was carried out on the sheet to form electrodes. And, a test piece of 1 cm² in area was
20 punched out from this sheet and a PTC element was obtained (comparative example 3).

Furthermore, comparative sample 4 was prepared as in the following (hereinafter, this comparative sample is referred to as "comparative example 4"). Crystalline high-density
25 polyethylene having softening point of about 130°C as a polymer component and conductive powder of 1 to 5 μ m in particle size were blended and kneaded on a roller mill heated about 140 to 200°C so that the content of the conductive

powder was 34 volume percent, and kneaded polymer material was obtained. Still more, TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C was used as conductive powder. The same treatment as in the above-mentioned example was carried out, then a test piece of 1 cm² in area was punched out from this sheet and a PTC element was obtained (comparative example 4).

Characteristic properties were tested on the example and comparative example 1 to 3 obtained as mentioned above. Well, as target properties of the PTC element were decided as follows: bonding strength of the electrode is 500 gf/cm² or more, which means sufficient reliability as an electrode, resistance at room temperature is 2 Ω · cm or less, and the ratio of resistance value after resistance value was suddenly increased to temperatures (after switching) to resistance value at room temperature (after switching R/room temperature R) is 10⁴ or more, which means that the PTC element sufficiently operates as over-current protective element and can be fully used as a sheet heater. Further, the target of resistance value at room temperature in cases of repeated switching of the PTC was decided to be 2 Ω · cm or less even after 50 times switching.

At first, lead wires were connected by soldering on the surfaces of electrodes of PTC elements (example and comparative example 1 to 3) obtained as mentioned above and surroundings of the electrodes were coated with epoxy resin. Samples for measuring bonding strength were thus prepared. Then, bonding strength of each electrode was measured by pulling a lead wire of each sample for measuring

corresponding to the example and comparative example 1 to 3.
Measurements are shown in Table 1.

[Table 1] Bonding strength of electrodes

Sample	Bonding strength (gf/cm ²)
Example	800 to 2300
Comparative example 1(Metal plate)	25 to 150
Comparative example 2 (Roughened metal plate)	850 to 2400
Comparative example 3 (Plating only)	30 to 170

As clearly shown in Table 1, the bonding strength of electrodes in the example was higher than those in comparative example 1 where a metal plate not roughened was used as electrodes and comparative example 3 where only plating was performed to form electrodes, and was about the same value as that in comparative example 2 where a roughened metal plate was used as electrodes. And the bonding strength of electrodes of the example was confirmed to be more than 500 gf/cm², the value is possible to sufficiently holding reliability as an electrode.

In the next place, resistance values at room temperature after 500 times of switching were measured on example and comparative example 1 to 3. Measurements are shown in Table 2. Well, a digital multimeter with direct current short needles was used for measuring resistivity at room temperature.

[Table 2] Resistivity at room temperature

Sample	Resistivity at room temperature ($\Omega \cdot \text{cm}$)
Example (TiC)	0.4
Example (WC)	0.5
Example (W_2C)	0.4
Example (ZrC)	0.4
Example (VC)	0.6
Example (NbC)	0.5
Example (TaC)	0.4
Example (Mo_2C)	0.5
Comparative example 1 (Metal plate)	110.0
Comparative example 2 (Roughened metal plate)	1.3
Comparative example 3 (Plating only)	320.0

As clearly shown in Table 2, in the examples, in cases where any of TiC, WC, W_2C , ZrC, VC, NbC, TaC, and Mo_2C is used, resistivity at room temperature was confirmed to be as low as target values of $2 \Omega \cdot \text{cm}$ or less.

To the contrary, in comparative example 1 where a metal plate not roughened was used as electrodes and comparative example 3 where only plating was performed to form electrodes, resistivity at room temperature was high, and it was found that it was quite difficult to obtain target values of $2 \Omega \cdot \text{cm}$ or less. It is considered that this is because of high contact resistance between electrodes and kneaded material sheets. On the other hand, in comparative example 2 where a roughened metal plate was used as electrodes, resistivity at room temperature was found to be as low as target values of $2 \Omega \cdot \text{cm}$ or less but higher than those in the examples. It is considered that this is because ohmic contact between the

electrodes and the kneaded material sheet is not so good as in the examples.

In the next place, a relationship between temperature and resistivity was measured on example. Measurements are
5 shown in Fig. 3. Well, measurements were made by using a four short needle method in an oil bath and a digital multimeter was used to determine resistivity.

As clearly shown in Fig. 3, in the example, resistivity at room temperature is as low as target value of $2\ \Omega \cdot \text{cm}$ or less
10 and the curve of temperature-resistivity greatly increases at temperatures roughly corresponding to the softening point (about 130°C) of crystalline high-density polyethylene used in the example. And the ratio of resistance value after
resistance value was suddenly increased to temperatures
15 (after switching) to resistance value at room temperature (after switching $R/\text{room temperature } R$) is higher than 10^8 and greatly exceeds the target value of 10^4 which means that the PTC element sufficiently operates as over-current protective element and can be fully used as a sheet heater.

Moreover, current of 10A (50V) was repeatedly caused to
20 flow through PTC elements (in the example and comparative example 1 to 4) obtained as mentioned above, respectively, and the changes of resistivity after operations were measured. Measurements are shown in Fig. 4.

As clearly shown in Fig. 4, in the example, initial
25 resistivity at room temperature was as low as target value of $2\ \Omega \cdot \text{cm}$ or less and continued to keep target values of $2\ \Omega \cdot \text{cm}$ or less after repeated current flow. And after several times

of repeated current flow, increase in resistivity at room temperature was found to be saturated.

To the contrary, in comparative example 1 where a metal plate not roughened was used as electrodes and comparative
5 example 3 where only plating was performed to form electrodes, initial resistivity at room temperature greatly exceeded the target value of $2\ \Omega \cdot \text{cm}$, and further, it is known that resistivity at room temperature greatly increases nearly in proportion to repeated current flow. On the other hand, in
10 comparative example 2 where a roughened metal plate was used as electrodes, initial resistivity at room temperature was as low as target values of $2\ \Omega \cdot \text{cm}$ or less but exceeded the target value of $2\ \Omega \cdot \text{cm}$ by repeated current flow, and no saturation is seen in the increase in resistivity at room
15 temperature.

Furthermore, in comparative example 4 where conductive powder was 34 volume percent, initial resistivity at room temperature was as low as target values of $2\ \Omega \cdot \text{cm}$ or less but exceeded the target value of $2\ \Omega \cdot \text{cm}$ by repeated current
20 flow, and it was found that stability to repeated current flow would not be obtained.

Now, in cases where metal powder is used as conductive powder, powder itself flocculates partly to form conductive routes and dielectric strength is decreased accordingly. And
25 in cases where any powder of carbon series, including carbon black and graphite, is used as a conductive powder, resistivity at room temperature exceeds the target value of $2\ \Omega \cdot \text{cm}$ because conductivities of powder materials are higher than

those of metal carbide powders.

Further, in cases where the filling amount of conductive powder is less than 35 volume percent, as mentioned above, stability to repeated current flow decreases and resistivity at room temperature may exceed the target value of $2\ \Omega \cdot \text{cm}$ according as the frequency of operations. On the other hand, in cases where the filling amount of conductive powder is more than 60 volume percent, it will be actually difficult to manufacture elements because of decrease in their manufacturing efficiency.

In addition, in cases where electrodes are formed by a method other than those of burying conductive powders and plating metal as in the example, as mentioned above, stability to repeated current flow decreases and resistivity at room temperature may exceed the target value of $2\ \Omega \cdot \text{cm}$ according as the frequency of operations. Well, when the filling amount of conductive powder is 45 volume percent or more, stability to repeated current flow was found to be further improved.

As mentioned above, in the first embodiment of the present invention, a conductive material was pressure sealed and buried on the surface of a formed composition material, in which conductive powder filler was blended and kneaded with a crystalline polymer component by 35 to 60 volume percent, so that the conductive material is partly exposed, and electrodes were formed by plating treatment on the surface of the formed composition material where the conductive material was partly exposed, and further, as conductive powder filler, at

least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C was used. Consequently, the adhesion between the PTC composition material and electrodes becomes good and the contact resistance between the two can be lowered. And it is possible to obtain a PTC element excellent in stability to repeated current flow.

In the next place, the second embodiment of the present invention will be explained in detail with reference to drawings.

Fig. 5 is a partial sectional view showing the PTC element related to the second embodiment of the present invention. As shown in Fig. 5, the PTC element 10 in the embodiment has formed composition material 12, conductive material 13 which is pressure sealed and buried so that the material is partly exposed from the surface 12A of formed composition material 12, and electrodes 14A and 14B formed by plating treatment on the surface 12A of formed composition material 12. And on the part where formed composition material 12 other than (plated) electrodes 14A and 14B is exposed, steam barrier layer 16 is coated.

Formed composition material 12 is quite the same as that in the above-mentioned embodiment 1 and was formed as follows: conductive powder filler using at least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C was blended and kneaded with a crystalline polymer component by 35 to 60 volume percent and then the mixture was formed. The crystalline polymer component in formed composition material 12 is composed of a polymer alloy in which one kind or two or

more kinds of thermoplastic polymers, for example, modified polyethylene or modified polypropylene, are mixed.

Nickel (Ni) foil is used in each of electrode 14A and 14B. Steam barrier layer 16 is formed by conducting steam barrier
5 treatment, for example, as mention later, such as coating with PVDC latex and others.

In the following, one example of the production method of PTC element 10 in the above-mentioned embodiment will be explained concretely with reference to Fig. 6. Fig. 6
10 indicates drawings to explain the production method of the PTC element of the example, (a) shows the formed composition material, (b) shows a state in which a conductive material is pressure sealed and buried so that the material is partly exposed from the surface of the formed composition material,
15 (c) shows a state in which electrodes are formed by plating treatment on the formed composition material, (d) shows steam barrier treatment, and (e) shows the PTC element treated with steam barrier treatment, respectively.

In Fig. 6, each process of (a), (b), and (c) is quite the
20 same as each process of (a), (b), and (c) in the first embodiment shown in Fig. 2.

In this example, steam barrier layer 16 was formed by coating PVCD latex 16a on the part except for plated electrodes (nickel foil) 14A and 14B in formed composition
25 material 12, that is, on part 12 C where the surface of formed composition material 12 is exposed, as shown in Fig. 6 (d), and PTC (resistant) element 10 of the example shown Fig. 6 (e) was consequently made.

Like this, in the PTC element of the example in which the steam barrier layer was formed by coating PVCD latex on the part except for plated electrodes (nickel foil) 14A and 14B, for example, even if 500 hours are passed after the PTC
5 element is put in a constant-temperature bath with $85^{\circ}\text{C} \times 90\%$ RH, resistivity after switching is stable and reliability is increased by 8 times compared to elements not formed steam barrier layer, and it was confirmed that more stable repeated current breaking can be achieved. Consequently, even if
10 switching operation is repeatedly performed at a state of high environmental humidity during stock and usage, stable resistance can be obtained.

As mentioned above, the present invention has been described in particular embodiments. However, the present
15 invention should not be limited to these embodiments but should be applied to other embodiments within the scope of the invention as defined by the appended claims.

For example, in the above-mentioned first and second embodiments, high-density polyethylene resin was used as a
20 main component of the formed composition material, but the main component is not limited to the resin. As main components of formed composition materials, polypropylene type, low-density polyethylene type and other type resins can be used, as well as high-density polyethylene resin.

25 Furthermore, in the above-mentioned second embodiment, steam barrier was formed by coating with PVCD latex, but in addition to this, methods of steam barrier treatment using substances with low steam permeability, for

example, polyvinylidene chloride and the like are considered.

[Industrial Usability]

As mentioned above, in the first embodiment of the
5 present invention, on the surface of the formed composition
material in which a conductive powder filler is blended and
kneaded with a crystalline polymer component by 35 to 60
volume percent, a conductive material is pressure sealed and
buried so that part of the conductive material is exposed, and
10 the surface of the formed composition material with partly
exposed conductive material is plated to form electrodes.
And at least one out of TiC , WC , W_2C , ZrC , VC , NbC , TaC , and
 Mo_2C is used as conductive powder filler. Consequently, the
adhesion between the PTC composition material and the
15 electrodes becomes good and contact resistance value between
the two can be reduced. And a PTC element with excellent
stability to repeated turning on electricity and its production
method can be obtained.

Besides, according to the second embodiment of the
20 present invention, in the PTC element and its production
method of the above-mentioned first embodiment, it is further
possible to effectively prevent the PTC element itself from
peeling from electrodes due to the effect of environmental
humidity. And a high reliable PTC element with good
25 stability and reproducibility to repeated use and its
production method can be provided.



What is claimed is:

1. A PTC element characterized in that the PTC element has a formed composition material in which a conductive powder filler is blended and kneaded with a crystalline polymer component by 35 to 60 volume percent, a conductive
5 material pressure sealed and buried so that the material is partly exposed from the surface of said formed composition material, and electrodes formed by plating on said surface of said formed composition material, and in that at least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC, and Mo₂C is used as said
10 conductive powder filler.
2. A PTC element according to claim 1, wherein Ni powder, Al powder, Cu powder, Fe powder, Ag powder, or graphite powder is included in said conductive material.
3. A PTC element according to claim 1, wherein said conductive powder filler is blended and kneaded with said crystalline polymer component by 45 to 60 volume percent to form said formed composition material.
5
4. A method of manufacturing a PTC element characterized in that the method has a process in which a formed composition material is obtained by means of blending and kneading at least one out of TiC, WC, W₂C, ZrC, VC, NbC, TaC,
5 and Mo₂C with a crystalline polymer component by 35 to 60 volume percent as a conductive powder filler, a process in



which after coating said formed composition material with a
conductive paste containing a conductive powder, said
conductive powder is pressure sealed and buried so that part
10 of said conductive powder is exposed from the surface of said
formed composition material, and a process in which said
surface of said formed composition material is plated to form
electrodes.

5. A method of manufacturing a PTC element according to
claim 4, wherein Ni powder, Al powder, Cu powder, Fe powder,
Ag powder, or graphite powder is used as said conductive
powder.

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6. A method of manufacturing a PTC element according to
claim 4, wherein said conductive powder filler is blended and
kneaded with said crystalline polymer component by 45 to 60
volume percent to form said formed composition material.

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7. A PTC element characterized in that the PTC element
has a formed composition material in which a conductive
powder filler using at least one out of TiC, WC, W_2C , ZrC, VC,
NbC, TaC, and Mo_2C is blended and kneaded with a crystalline
5 polymer component by 35 to 60 volume percent, a conductive
material which is pressure sealed and buried so that it is
partly exposed from the surface of said formed composition
material, electrodes formed by plating on said surface of said
formed composition material, and a steam barrier layer formed
10 in the part other than said plated electrodes.



8. A PTC element according to claim 7, wherein said crystalline polymer component is a polymer alloy in which at least one kind of thermoplastic polymers is mixed.

5 9. A method of manufacturing a PTC element characterized in that the method has a process in which a formed composition material is obtained by means of blending and kneading at least one out of TiC , WC , W_2C , ZrC , VC , NbC , TaC , and Mo_2C with a crystalline polymer component by 35 to 60
10 volume percent as a conductive powder filler, a process in which after coating said formed composition material with a conductive paste containing a conductive powder, said conductive powder is pressure sealed and buried so that part of said conductive powder is exposed from the surface of said
15 formed composition material, a process in which said surface of said formed composition material is plated to form electrodes, and a process in which a steam barrier treatment is carried out in the part other than said plated electrodes.