(57) Abrégé/Abstract:
A manufacturing method of a bead inductor comprises the steps of forming a molded body of a resin or a rubber including a powdery magnetic substance with a conductor coil formed by winding a length of metallic wire coated thereon for insulation embedded therein; cutting the both ends of the molded body so as to expose the ends of the conductor coil; and attaching external terminals to the exposed ends of the conductor coil so as to be electrically connected. The connecting reliability between the conductor coil and the external terminals is increased in the bead inductor manufactured by the method. Convex portions protruding from the end surfaces of the molded body are formed on the both ends of the conductor coil, which are exposed by cutting the molded body, so that the external terminals are attached to be electrically connected to the convex portions.
ABSTRACT OF THE DISCLOSURE

A manufacturing method of a bead inductor comprises the steps of forming a molded body of a resin or a rubber including a powdery magnetic substance with a conductor coil formed by winding a length of metallic wire coated thereon for insulation embedded therein; cutting the both ends of the molded body so as to expose the ends of the conductor coil; and attaching external terminals to the exposed ends of the conductor coil so as to be electrically connected. The connecting reliability between the conductor coil and the external terminals is increased in the bead inductor manufactured by the method. Convex portions protruding from the end surfaces of the molded body are formed on the both ends of the conductor coil, which are exposed by cutting the molded body, so that the external terminals are attached to be electrically connected to the convex portions.
METHOD OF MANUFACTURING BEAD INDUCTOR AND THE BEAD INDUCTOR PRODUCED THEREBY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a manufacturing method of a bead inductor and a bead inductor produced thereby for use in noise controlling and others.

2. Description of the Related Art

As a noise-controlling device, especially a device for a microprocessor, for example, which is required to pass a large electric current therethrough, a bead inductor has been used. A bead inductor which is an example of an experimental unpublished device is formed of a resin or a rubber including a powdery magnetic substance such as ferrite powder with a conductor coil embedded therein. In this bead inductor, a conductor coil is embedded into a resin or a rubber by injection molding, etc., to form a molded body which is cut off at the both ends thereof to expose the both ends of the inside coil. Then, metal caps are connected thereto by conductive resin paste or spot welding as external terminals.

Figs. 5 and 6 are sectional views for illustrating a method for manufacturing the bead inductor. Referring to Figs. 5 and 6, a metallic mold for injection molding to manufacture the bead inductor is formed of an upper mold 1
and a lower mold 2. In the upper mold 1 is formed a cavity 3, which is a space to be molded of a resin. In the lower mold 2, a pin 4 is provided so as to be disposed in the cavities 3 when the upper mold 1 and the lower mold 2 are mated with each other. The upper mold 1 has a gate 1a for supplying a melting resin into the cavity 3.

In order to manufacture a molded body of the bead inductor using the metallic mold shown in Fig. 5, the pin 4 is inserted into a conductor coil, which is formed by winding a length of metallic wire such as a copper wire coated by a polyester resin, etc., for insulation. Then, the melting resin including a powdery magnetic substance such as ferrite powder is injected into the cavity 3 from the gate 1a. Thereby, the outer portion of the conductor coil inserted into the pin 4 therein is molded of the melting resin.

Fig. 6 is a sectional view showing the state of the outside portion of a coil 5 molded in this manner. Then the pin 4 is removed and the same resin as the outside portion of the coil 5 is injected into the space produced by the removing to mold the inside of the coil 5 of the melting resin, so that the coil 5 is embedded in the resin.

The both ends of the molded body obtained in this manner are cut off by a dicing saw, etc., such that the ends of the coil embedded in the resin of the molded body are
exposed.

Fig. 7 is a side view showing the molded body after the cutting in this manner thereof, while Fig. 8 is a plan view thereof. A molded body 7 is formed by embedding the conductor coil 5 into a resin molding 6. On one of the cutting planes 7a of the molded body 7, one end portion 5a of the conductor coil 5 is exposed. On the other of the cutting planes 7b of the molded body 7, the other end portion 5b of the conductor coil 5 is exposed. In a conventional manufacturing method, metallic caps as external terminals are attached so that the end portions 5a and 5b of the conductor coil 5 are electrically connected thereto by conductive resin paste or spot welding. Solder may be used to attach the metallic cap, and in this case, solder paste, etc., is coated on the end portions of the conductor coil exposed on the end planes of the molded body or on the metallic caps.

In a conventional bead inductor, the conductor coil inside of the molding is electrically connected to the external terminal by conductive resin paste, spot welding, etc., as described above, there has been a problem of a low degree of reliability in the electrical connection between the conductor coil and the external terminal. That is, it is difficult to secure the spot welding on the ends 5a and 5b of the conductor coil 5 in the respective cutting planes.
7a and 7b of the molded body 7, because the surfaces of the ends are flat ones as shown in Fig. 7, resulting in a low degree reliability in connecting when the external terminal such as a metal cap is welded thereon. When the external terminals such as the metal caps are bonded on the ends 5a and 5b of the conductor coil 5 by conductive resin paste, the connecting reliability is also low because of poor adhesive properties.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a manufacturing method of a bead inductor and the bead inductor produced thereby being capable of improving the connecting reliability between the conductor coil and the external terminal.

In accordance with one aspect of the present invention, a method for manufacturing a bead inductor comprises the steps of forming a molded body of at least one of a resin and a rubber including a powdery magnetic substance with a conductor coil formed by winding a length of metallic wire coated thereon for insulation embedded therein; cutting the both ends of the molded body so as to expose ends of the conductor coil; forming convex portions on the ends of the conductor coil, which is exposed by the cutting step; and attaching external terminals to the convex portions so as to
be electrically connected.

According to the one aspect of the present invention, as the convex portion is formed on the end of the conductor coil, the connection by spot welding or soldering is to be easy so as to further securely connect the conductor coil to the external terminal electrically. Therefore, the connecting reliability between the conductor coil and the external terminal can be increased.

The step of forming convex portions according to the one aspect of the present invention may be achieved by plating the ends of the conductor coil. The method of plating is not specifically limited. Electrolytic plating or electroless plating may be utilized. In the case of the electrolytic plating, the plating may be performed in a plurality of layers, for example. In order to improve solder wetting properties in spot welding or soldering, after Ni layer plating is given, Sn layer plating may be given thereon.

The step of forming convex portions according to the one aspect of the present invention may be achieved by applying solder on the ends of the conductor coil. As a method for applying solder, for example, the convex portions made of solder may be formed by immersing the ends of the conductor coil on the surface of the molded body into a melting soldering bath after coating flux thereon so as to
deposit the solder on the ends of the conductor coil.

In accordance with the one aspect of the present invention, when the step of forming convex portions is achieved by applying solder on the ends of the conductor coil, the solder having a high melting point may be utilized. When the inductor is mounted on a substrate by generally used flow and reflow soldering, general solder can be used for forming the convex portion. When occasion demands that the inductor is soldered on a substrate at a high temperature, it is preferable that the convex portion be formed of solder having a high melting point, which is the so-called high-temperature solder.

The step of forming convex portions according to the one aspect of the present invention may be achieved by sandblast treating of the ends of the molded body so as to expose the ends of the conductor coil by scraping the surfaces of the ends of the molded body. As the convex portion is formed so that the conductor coil is exposed to protrude by scraping the surfaces of the ends of the molded body, there is no possibility of exfoliation of the convex portion, which results in further improvement of connecting reliability. In addition, when the end surface of the molded body is treated by sandblast, insulation coating on the exposed conductor coil is also removed by sandblast to improve the electrical connection.
In accordance with another aspect of the present invention, a bead inductor comprises a conductive coil formed by winding a length of metallic wire coated thereon for insulation; a molded body formed of at least one of a resin and a rubber including a powdery magnetic substance with the conductor coil embedded therein so that the ends of the conductor coil are exposed at the both ends of the molded body; convex portions formed on the exposed ends of the conductor coil at the both ends of the molded body so as to be electrically connected thereto; and external terminals attached to each of the both ends of the molded body so as to be electrically connected to the convex portions. The bead inductor according to the another aspect of the present invention can be manufactured by the manufacturing method in accordance with the one aspect of the present invention.

The external terminals according to the another aspect of the present invention may be metallic caps fitted to the both ends of the molded body.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view showing a molded body with convex portions formed thereon according to an embodiment of the present invention;

Fig. 2 is a plan view showing the molded body with the convex portions formed thereon according to the embodiment
of the present invention;

Fig. 3 is a side view showing a bead inductor according to the embodiment of the present invention;

Fig. 4 is a plan view showing the bead inductor according to the embodiment of the present invention;

Fig. 5 is a sectional view showing a metallic mold of injection molding for forming the molded body with a conductive coil embedded therein;

Fig. 6 is a sectional view showing the metallic mold of injection molding for forming the molded body with the conductive coil embedded therein and the portion of the molded body outside of the coil;

Fig. 7 is a side view showing a conventional molded body; and

Fig. 8 is a plan view showing the conventional molded body.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 is a side view showing a molded body with convex portions formed thereon according to an embodiment of the present invention, while Fig. 2 is a plan view thereof. The molded body shown in Figs. 1 and 2 is obtained by forming convex portions 8a and 8b on the both ends 5a and 5b of a conductor coil 5 of a molded body 7, shown in Figs. 7 and 8, produced by the same manufacturing process as a conventional
one. The convex portions 8a and 8b are generally formed in an annular shape along the ends 5a and 5b of the conductor coil, respectively, as shown in Fig. 2.

In the case that the convex portions 8a and 8b are formed by electrolytic plating, for example, the convex portions can be formed by electrolytic plating, immersing the molded body shown in Figs. 7 and 8 in an electrolytic plating bath so that the conductive coil is connected thereto so as to be electrodes.

In the case that the convex portions 8a and 8b are formed by soldering, the convex portions 8a and 8b made of solder can be formed by coating flux on the ends 5a and 5b of the conductor coil 5 which is exposed to cutting planes 7a and 7b of the molded body 7 and by immersing them into a melting soldering bath so as to deposit the solder on the ends 5a and 5b.

In the case that the convex portions 8a and 8b are formed by sandblast, the cutting planes 7a and 7b of the molded body 7 are treated by sandblast, respectively. The surfaces of the resin molding 6 on the cutting planes 7a and 7b of the molded body 7 are scraped such that the ends 5a and 5b of the conductor coil 5 are exposed so as to protrude. The ends 5a and 5b exposed in this manner are to be the convex portions 8a and 8b, respectively. The exposing portion is coated by a thin insulating film thereon because the conductor coil 5 is formed of a metallic wire
coated for insulating. As the thin insulating film is removed by the sandblast, the inside metallic wire is in an exposed state on the surfaces of the convex portions 8a and 8b.

Figs. 3 and 4 are a side view and a plan view, respectively, showing the state in which metallic caps 9 and 10 are attached to the both ends of the molded body 7 shown in Figs. 1 and 2 so as to be the bead inductor. As shown in Fig. 3, the metallic cap 9 is disposed so as to be contact with and be electrically connected to the convex portion 8a on the end 5a of the conductor coil 5. The metallic cap 10 is also disposed so as to be contact with and be electrically connected to the convex portion 8b on the end 5b of the conductor coil 5.

As for the method for attaching the metallic caps 9 and 10 so as to be electrically connected, there are methods by spot welding and soldering. The coating of conductive paste may be also used.

As the convex portions 8a and 8b of the both ends of the molded body 7 are in the state of protruding from the cutting planes 7a and 7b as shown in Fig. 3, spot welding and soldering are easy to be performed as well as coating of conductive paste, etc. Therefore, the metallic caps 9 and 10 can be attached in conditions securing sufficient electrical connectibility.
As described above, when the metallic caps are attached to the convex portions 8a and 8b, spot welding, soldering, coating of conductive paste, etc. can be utilized. When the convex portion is formed of solder, the metallic cap is abutted to the convex portion to be heated as it is, so that the metallic cap can be attached by melting the solder.

While in the above-described embodiment, a resin including a powdery magnetic substance has been explained as the resin including ferrite powder for an example, the present invention is not limited to this powder and a resin including other various powdery magnetic substances may be used. A rubber including a powdery magnetic substance may be also used.

In accordance with one aspect of the present invention, by forming convex portions on the ends of the conductor coil in the molded body after cutting, the electrical connection between the convex portions and external terminals can be achieved. Therefore, the connection between the conductor coil and the external terminal by spot welding, adding solder, coating conductive paste, etc., is to be easy to further securely connect the conductor coil to the external terminal electrically. Accordingly, the connecting reliability between the conductor coil and the external terminal can be increased.

The step of forming convex portions according to the
one aspect of the present invention may be achieved by plating the ends of the conductor coil. This also enables to increase the connecting reliability between the conductor coil and the external terminal.

In accordance with the one aspect of the present invention, when the step of forming convex portions is achieved by adding solder on the ends of the conductor coil, the connecting reliability between the conductor coil and the external terminal may be also increased. As the convex portion is formed of solder, when it is connected to the external terminal, soldering can be achieved by heating the convex portion to melt the solder thereof.

In accordance with the one aspect of the present invention, when the step of forming convex portions is achieved by adding solder on the ends of the conductor coil, by using solder having a high melting point, the forming may be applied when the inductor is mounted on a substrate at a higher temperature than a general flow and reflow soldering temperature.

According to the one aspect of the present invention, the convex portion may be formed by sandblast treating of the ends of the molded body so as to expose the ends of the conductor coil by scraping the surfaces of the ends of the molded body. This also enables to increase the connecting reliability between the conductor coil and the external
terminal.

In accordance with another aspect of the present invention, as the external terminals are disposed so as to be electrically connected to the convex portions formed on the exposed ends of the conductor coil at the both ends of the molded body, the connecting reliability between the conductor coil and the external terminal can be increased.

The external terminals according to the another aspect of the present invention may be conventionally generally used metallic caps as external terminals. This enables to obtain a chip inductor having a high degree of connecting reliability between the metallic cap as an external terminal and the conductor coil.
WHAT IS CLAIMED IS:

1. A method for manufacturing a bead inductor, comprising the steps of:
   forming a molded body of at least one of a resin and a rubber including a powdery magnetic substance with a conductor coil formed by winding a length of metallic wire coated thereon for insulation embedded therein;
   cutting the both ends of the molded body so as to expose ends of the conductor coil;
   forming convex portions on the ends of the conductor coil, which is exposed by said cutting step; and
   attaching external terminals to the convex portions so as to be electrically connected.

2. A method according to Claim 1, wherein said step of forming convex portions is achieved by plating the ends of the conductor coil.

3. A method according to Claim 1, wherein said step of forming convex portions is achieved by adding solder on the ends of the conductor coil.

4. A method according to Claim 3, wherein said step of forming convex portions is achieved by adding solder having
a high melting point.

5. A method according to Claim 1, wherein said step of forming convex portions is achieved by sandblast treating of the ends of the molded body so as to expose ends of the conductor coil by scraping the surfaces of the ends of the molded body.

6. A bead inductor comprising:
   a conductive coil formed by winding a length of metallic wire coated thereon for insulation;
   a molded body formed of at least one of a resin and a rubber including a powdery magnetic substance with said conductor coil embedded therein so that the ends of said conductor coil are exposed at the both ends of said molded body;
   convex portions formed on the exposed ends of said conductor coil at the both ends of said molded body so as to be electrically connected thereto; and
   external terminals attached to each of the both ends of said molded body so as to be electrically connected to said convex portions.

7. A bead inductor according to Claim 6, wherein said external terminals are metallic caps which are respectively
fitted to both ends of said molded body.