

ENAMELLED WIRE, METHOD OF SOLDERING THE WIRE AND ELECTRO-ACOUSTIC TRANSDUCER

5

TECHNICAL FIELD

The present invention relates to an enamelled wire for use as a coil of small and light-weight electro-acoustic transducer such as a micro speaker, a receiver, a sounder or the like, built in a portable telephone unit or the like mobile communication apparatus. The present invention also includes a method of soldering the wire, as well as an electro-acoustic transducer employing it.

BACKGROUND ART

15 A conventional technology used for manufacturing an electro-acoustic transducer is described with reference to FIG. 5 through FIG. 7.

FIG. 5 shows a cross sectional side view of a sounder for use in a mobile communication apparatus. FIG. 6 is a cross sectional view of an enamelled wire for forming a coil, which is a key portion of the sounder. FIG. 7 is a perspective view used to describe how enamelled wire is soldered by means of laser irradiation.

Referring to FIG. 5, an enamelled wire 1 is wound to form a coil 1a disposed on a plate 3 having a centre pole 2. A terminal 4 is resin-moulded in a bottom case 4a with at least a soldering portion exposed outside. The terminal is provided at the exposed portion with a land for connection with the enamelled wire 1. A ring-shaped magnet 5 is fixed on the plate 3. Above the magnet 5 is a diaphragm 6, which is disposed with a certain clearance from the magnet 5. A small piece of magnetic material is attached on the diaphragm 6 at the centre. An upper case 7 is provided with a sound radiation hole 8.

30 Enamelled wire 1 constituting the coil 1a is described with reference to

FIG. 6. There is a core wire 1b of copper or an copper alloy, which is covered around the outer surface with an insulating film 1c, and a hot-melt layer 1d is covering the insulating film 1c.

During the enamelled wire is wound around the centre pole 2 for forming the coil 1a, the hot-melt layer 1d is softened or melted by hot air blown thereto, or by other means. When the heating with hot air is stopped, the hot-melt layer 1d solidifies again, and as a result the enamelled wire 1 stays in a coiled shape.

The end part of enamelled wire 1 forming the coil 1a is soldered to the terminal 4 after the insulating film 1c is stripped.

Generally practised process of the soldering is; either stripping the insulating film 1c using a CO₂ laser or the like before soldering and then soldering the wire, or conducting the stripping and the soldering at the same time using a laser beam.

A method where the process steps of stripping the insulating film 1c and soldering of the wire are made simultaneously with a laser beam is described below with reference to FIG. 7.

A conventional soldering apparatus consists mainly of a laser oscillator 10, an optical fibre 11, a projection lens 12 and a string solder 13. Laser beam from the laser oscillator 10 is led via the optical fibre 11 to the projection lens 12 to be projected to the outside. The irradiated laser beam is absorbed by the land of terminal 4 and the enamelled wire 1, and the beam is converted into thermal energy. When the land of terminal 4 is heated to reach a solder melting temperature, the string solder 13 is delivered thereto. The heat energy provided for soldering removes the hot-melt layer 1d and the insulating film 1c away by melting, evaporation or sublimation, and solders the enamelled wire 1 to the land.

In the above-described method of soldering, where the covering film and layer are stripped away prior to soldering, cost of bonding tends to increase because of the increased process step of soldering. In addition, the CO₂ laser used for stripping the insulating film 1c readily oxidizes the land, as a result, the wetting property of the land against solder deteriorates.

While in the method where stripping of insulating film 1c and soldering of wire are conducted simultaneously by laser beam irradiation, since the normally-used core wire 1b of enamelled wire 1 is as fine as 0.1 mm in diameter, the enamelled wire 1 easily breaks by a slightly increased output of the laser beam which leads to an excessive generation of heat energy. On the other hand, if the heat energy is insufficient, the insulating film 1c is stripped imperfectly, which tends to cause soldering troubles such as a tunnelling solder, or the like.

As described in the foregoing, conventional soldering method using a laser beam has a drawback that it accompanies a precise process control.

The present invention addresses the above problems and aims to provide an enamelled wire with which a tune needed for laser-soldering a wire on a soldering land can be shortened and a rate of occurrence of the tunnelling solder and other soldering troubles can be decreased. The present invention also includes a method of soldering the enamelled wire, as well as a soldering apparatus using the enamelled wire of the present invention.

DISCLOSURE OF THE INVENTION

In accordance with a first aspect of the invention, there is provided an enamelled wire comprising: a core wire of copper or a copper alloy; an insulating coated layer covering said core wire; and a melting layer covering said insulating coated layer; wherein said insulating coated layer is formed of a coloured resin material which is able to absorb a laser beam.

In accordance with a second aspect of the invention, there is provided a method of soldering an enamelled wire comprising the steps of: irradiating a laser beam to an enamelled wire comprising: a core wire made of copper or a copper alloy; an insulating coated layer covering said core wire, said coated layer being made of a material which absorbs the laser beam; and a melting layer covering said insulating coated layer; stripping at least a part of said insulating coated layer by the laser beam; and soldering said core wire to a soldering portion by the laser beam.

In accordance with a third aspect of the invention, there is provided an electro-acoustic transducer comprising: a plate having a centre pole; a coil disposed on said

3a

plate, said coil being formed of an enamelled wire comprising a core wire made of copper or a copper alloy metal, coloured insulating coated layer to absorb a laser beam, covering said core wire and a melting layer covering said insulating coated layer; a terminal for connection with said enamelled wire moulded with a resin with at least a soldering portion exposed outside; a magnet fixed on said plate; a diaphragm disposed above said magnet with a space to said centre pole, said diaphragm having a magnetic material disposed thereon; and a resin-mould body having an empty space in at least a part underneath said soldering portion of said terminal.

In an enamelled wire of the present invention, the insulating coated layer is coloured for a better absorption of a laser beam, while the hot-melt layer is transparent to the laser beam. When soldering an enamelled wire of present invention with a laser beam, the insulating coated layer can be stripped away without making output of the laser very high, since an absorption against the irradiated laser beam is high in the insulating coated layer. As a result, a trouble of broken enamelled wire can be avoided, and the reliability in soldering between the end of enamelled wire and the soldering land is improved.

An electro-acoustic transducer of the present invention includes a vacant space provided in a resin moulded body at least in a part underneath the soldering land. With an electro-acoustic transducer of the present invention, the efficiency of laser beam utilization Increases and soldering quality and the reliability

improve.

BRIEF DESCRIPTION OF THE DRAWINGS

5 FIG. 1 is a cross sectional view of an enamelled wire having an insulating coated layer in accordance with an exemplary embodiment of the present invention.

 FIG. 2 is a perspective view used to describe a soldering of the enamelled wire by laser beam irradiation.

10 FIG. 3 is a perspective view showing a relationship between size of soldering land and diameter of laser beam spot.

 FIG. 4 is a perspective view of a resin mould case provided in accordance with another exemplary embodiment of the present invention.

 FIG. 5 is a cross sectional side view of a conventional sounder.

15 FIG. 6 is a cross sectional view of a conventional enamelled wire.

 FIG. 7 is a perspective view used to describe how soldering is made using a laser beam irradiation.

BEST MODE FOR CARRYING OUT THE INVENTION

20

 An enamelled wire 21 in accordance with the present invention, a method of soldering the enamelled wire, as well as the soldering apparatus, are described in the following with reference to FIG. 1 through FIG. 4. The portions using the same conventional technology are represented by the same reference numerals used for the prior art, and descriptions to such portions are omitted. The enamelled
25 wire 21 is wound into a coil through a conventional technology, so description on coiling method is omitted here.

First Embodiment 1

30 FIG. 1 shows a cross sectional view of an enamelled wire manufactured in

accordance with an exemplary embodiment of the present invention. FIG. 2 is a perspective view showing how the wire is soldered. FIG. 3 is a perspective view used to show a relationship between size of soldering land and diameter of laser beam spot. These drawings relate mainly to the embodiments relevant to claim 1 through claim 9 of the present invention.

Referring to FIG. 1, an enamelled wire 21 comprises a core wire 21a made of copper or a copper alloy, an insulating coated layer 21b of coloured polyurethane resin covering the outer surface of core wire 21a, and a transparent hot-melt layer 21c covering the outer surface of the insulating coated layer 21b.

A method of soldering the above-configured enamelled wire 21 on the land of terminal 4 by means of laser irradiation is described referring to FIG. 2.

In FIG. 2, a land 22 is made of a thin metal sheet, and provided with a soldering portion 22a. A resin mould case 23 is formed integrally with a terminal 4 so that the surface of land 22 is exposed to the outside.

Soldering experiment was conducted with the enamelled wire 21 of the present invention using a CO₂ laser under specific laser irradiation conditions. In the experiment, stripping of the insulating coated layer 21b and the soldering were done simultaneously. Results of the experiment show that there was no soldering problems (number of samples : N = 300).

Whereas, in the same experiment conducted under the same conditions using a conventional enamelled wire, one sample was rejected due to bad soldering (N = 200). Thus it has been confirmed that the connection trouble was eliminated by the use of an enamelled wire 21 of the present invention.

Supposed reason for the eliminated soldering trouble is that colour of the insulating coated layer 21b in the present exemplary embodiment is green, while the insulating film 1c of conventional enamelled wire 1 has a colour that is transparent to the laser beam. The green-colour insulating coated layer 21b efficiently absorbed the irradiated laser beam; as a result, it was surely melted and stripped away and the core wire 21a of enamelled wire 21 had a good contact with molten solder. This seems to be a reason why the enamelled wire 21 and the

soldering portion 22a connected in a stable manner.

Although the insulating coated layer 21b in the present embodiment has a colour green, those blue-coloured films also exhibited the same effects. Thus the colours given to the insulating coated layer 21b help increasing the absorption of laser beam and heat the film effectively. It seems that an insulating coated layer 21b was melted and stripped away thoroughly and the soldering finished well by taking advantage of the above-described factors, without irradiating a high amount of laser beam energy.

An insulating coated layer 21b may be coloured by any conventional means using a dye or a pigment. The absorption wavelength of such colouring means is not required to be existing within the range of visible lights. Namely, the colouring is effective also to the YAG laser, CO₂ laser or other kinds of laser beams whose oscillation wavelength is not within the range of visible lights. In this case, the insulating coated layer should be provided with a colouring means that has an absorption band corresponding to the oscillation wavelength.

Although in the present embodiment a CO₂ laser apparatus was used because of its general availability and a high energy, high output semiconductor lasers may of course be used instead, which oscillate beams in red, green ultraviolet or other colours.

It is to be noted too, that once the melting/stripping is initiated at a part of insulating coated layer 21b, the stripped area is expanded by a molten solder, and as a result the soldering can be completed well.

Furthermore, as shown in FIG. 3, when a soldering portion 22a of land 22 is made to have a same shape as that of laser beam spot 24, unwanted heat diffusion can be avoided to obtain a highest heating efficiency. This leads to a shorter soldering time.

Still further, the soldering time can be shortened by making the size of the soldering portion 22a of land 22 approximately identical to that of the laser beam spot 24. Under such a configuration, the heat diffusion can be suppressed and the heating efficiency maximizes.

Second Embodiment

FIG. 4 is a perspective view of a resin case of a receiver provided in accordance with another exemplary embodiment of the present invention. It shows how soldering is made on a soldering land which is made of a thin metal sheet moulded in the resin. The drawing relates mainly to claim 10 of the present invention.

Referring to FIG. 4, a resin mould case 26 is provided with an empty space 26a underneath a soldering portion 25a of land 25. The empty space 26a is provided in order to suppress a diffusion of heat caused by a laser beam spot irradiation into the resin casing 26, and to further increase the efficiency of soldering. The empty space 26a may be penetrating through the resin casing 26 to a bottom surface, in which case, it can be utilized also as a screw hole for fixing.

There can be another means for improving the heating efficiency hence shortening the soldering time. The land 25 may be plated with a solder or tin, or provided with a flux layer on the surface to increase the laser beam spot absorption. By so doing, the reliability of soldering may also be improved.

Though, in the foregoing descriptions only a hot-melt layer of an enamelled wire has been explained, it should be noticed that the melting layer is not limited to a hot-melt type. The present invention may employ enamelled wires having a melting layer which is softened or glued by a solvent, or a self-adhesive layer can be used for the same purpose. Also, in the foregoing descriptions the hot-melt layers have been described to be transparent to the laser beam spot. However, it is not requested that the layer is totally transparent; but, what is essential is that a hot-melt layer absorbs less laser beam spot relative to an insulating coated layer of the wire.

A soldering method in the present invention can be applied on those enamelled wires having no melting layer.

INDUSTRIAL APPLICABILITY

An enamelled wire having an insulating coated layer in accordance with the present invention can be stripped of the insulating coated layer efficiently by a laser beam spot irradiation during soldering process. As a result, the stripping of insulating coated layer and the soldering can be conducted simultaneously; that means that the use of an enamelled wire of the present invention can shorten a time needed for a soldering work during assembly of an apparatus. Problems due to bad soldering, such as a tunnelling soldering, can also be reduced. Thus the enamelled wires of the present invention are expected to make a significant contribution in the manufacturing productivity as well as in the reliability of electric devices including the electro-acoustic transducers and the like.

CLAIMS

5

1. An enamelled wire comprising:

a core wire of copper or a copper alloy;

an insulating coated layer covering said core wire; and

a melting layer covering said insulating coated layer;

10

wherein said insulating coated is formed of a coloured resin material which is able to absorb a laser beam.

2. The enamelled wire of claim 1, wherein said material is coloured with a dye or a pigment.

15

3. The enamelled wire of claim 1, wherein said melting layer is transparent to said laser beam.

4. The enamelled wire of claim 1, wherein said melting layer softens or melts with heat.

20

5. The enamelled wire of claim 1, wherein said insulating coated layer is able to absorb a laser beam oscillated from one of a CO₂ laser, a YAG laser and a semiconductor laser.

25

6. A method of soldering an enamelled wire comprising the steps of:

irradiating a laser beam to an enamelled wire comprising:

a core wire made of copper or a copper alloy;

an insulating coated layer covering said core wire, said coated layer being made of a material which absorbs the laser beam; and

a melting layer covering said insulating coated layer;

5 stripping at least a part of said insulating coated layer by the laser beam; and

soldering said core wire to a soldering portion by the laser beam.

7. The method of soldering an enamelled wire of claim 6, wherein said
10 soldering portion has the same shape as said laser beam spot.

8. The method of soldering an enamelled wire of claim 6, wherein the size of said soldering portion is approximately identical to the diameter of said laser beam.

15

9. The method of soldering an enamelled wire of claim 6, further comprising a step of providing an empty space underneath the soldering portion of a soldering land.

20 10. An electro-acoustic transducer comprising:

A: a plate having a centre pole;

B: a coil disposed on said plate, said coil being formed of an enamelled wire comprising a core wire made of copper or a copper alloy metal, a coloured insulating coated layer to absorb a laser beam, covering said wire and a melting
25 layer covering said insulating coated layer;

C: a terminal for connection with said enamelled wire moulded with a resin with at least a soldering portion exposed outside;

D: a magnet fixed on said plate;

10a

E: a diaphragm disposed above said magnet with a space to said centre pole, said diaphragm having a magnetic material disposed thereon; and

F: a resin-mould body having an empty space in at least a part
5 underneath said soldering portion of said terminal.

ABSTRACT

An enamelled wire with an insulating coated layer of high laser beam
5 absorption and with a melting layer transparent to the laser beam. The high laser
beam absorption makes stripping of the insulating coating layer easy without
increasing an output of the laser beam extremely large. As a result, possible wire
breakage at soldering can be avoided and soldering reliability improves in
assembling the small electro-acoustic transducers. An electro-acoustic transducer
10 of the present invention is provided in the resin-moulded body with an empty
space in at least a place underneath a portion of soldering land, on which a laser
beam is irradiated. Apparatus comprising the electro-acoustic transducer of the
present invention can provide a well-stabilized soldering quality and a high
reliability.