

Electrical resistor, in particular for medical implants

The invention relates to an electrical resistor, in particular for use as a component in a medical implant.

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An implant of this kind can be an implantable defibrillator, for example. A defibrillator of this kind must be able to discharge a charged capacitor within a short space of time so as to return to a controlled starting state. The electrical resistor necessary for this purpose must absorb high energies within a short space of time. Since the resistor is inserted in particular during the final assembly of the defibrillator, it must be possible to join the resistor in an integrally bonded manner, in particular by means of laser welding, so as to satisfy the electrical and mechanical requirements.

15 Relatively complex process steps are provided in the prior art for this purpose. Here, the resistor is firstly etched from a basic material and is galvanically metallised locally by means of Ni and Au. By means of this metallisation a connection band is then connected by means of resistance welding. The weld seam is then insulated with a cover film.

20 Furthermore, US 9 265 170 B2 discloses an IC with a layered structure, wherein a connection element for the electrical and mechanical connection is mounted subsequently.

According to the techniques disclosed herein, there is provided an electrical resistor which can be produced relatively easily and yet still allows the connection elements of the resistor to be joined by means of welding or soldering.

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Aspects of the invention are defined in the independent claims. Advantageous embodiments are specified in the corresponding dependent claims and will be described hereinafter.

30 An electrical resistor is disclosed, comprising:

- a resistance conductor, which is applied to a carrier layer, and

- two connection elements, which are electrically conductively connected to the resistance conductor.

5 The two connection elements are configured to each be welded or soldered to an electrical contact in order to electrically contact the resistor, and that the resistance conductor, for each connection element, has a region overlapping the corresponding connection element, which region electrically conductively connects the corresponding connection element.

10 In one exemplary resistor, each of both connection elements is formed in one piece, e.g. is formed or designed as a metal sheet.

15 The resistance conductor can be formed as a coating of the carrier layer. In particular the resistance conductor can be formed by sputter deposition or vapour deposition of an electrically conductive substance or material onto the carrier layer.

20 In one exemplary resistor, the resistance conductor is arranged on a first side of the carrier layer, wherein a metal layer is arranged on a side of the carrier layer facing away from the first side, which metal layer forms a heat sink for absorbing Joule's heat. The metal layer can be applied directly on the second side of the carrier layer or can be connected thereto in an integrally bonded manner via an adhesive layer. The carrier layer for example can be a film. The carrier layer for example can consist of a plastic, a polymer or a polyimide or can comprise a substance of this kind.

25 In one exemplary resistor, the connection elements are arranged on the first side of the carrier layer or are connected thereto in an integrally bonded manner.

30 In one exemplary resistor, the connection elements form portions of the metal layer and/or that the connection elements are arranged on the second side of the carrier layer. The connection elements can be connected to the second side of the carrier layer for example via an adhesive layer.

In one exemplary resistor, the various regions of the resistance conductor each form a plated through-hole, wherein said regions each extend through a through-opening in the carrier layer and electrically conductively connect the corresponding connection element.

- 5 In one exemplary resistor, a metal layer is applied to each of the regions of the resistance conductor for local resistance reduction, such that each region is arranged between the corresponding metal layer and the corresponding connection element. Each metal layer can consist of Cu or can comprise Cu. Each metal layer can be formed by deposition of a conductive material (for example Cu) on the corresponding region.

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In one exemplary resistor, the metal layer or heat sink comprises one of the following substances or consists of one of the following substances: Cu; an alloy comprising Cu and Ni; Ni; Nb; Ta; a high-grade steel; an alloy comprising Cu, Ni and Mn; an alloy comprising 55 % by weight Cu, 44 % by weight Ni and 1 % by weight Mn.

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In one exemplary resistor, is also provided that the two regions of the resistance conductor are connected to one another via a meandering portion of the resistance conductor (for example in each case integrally or in one piece).

- 20 In one exemplary resistor, the resistance conductor consists of one of the following substances or comprises one of the following substances: Ti, Au, Cu, Ni, Pd, Nb, Cr.

In one exemplary resistor, the resistor has a first and a second insulation layer, wherein the first insulation layer is connected or adhesively bonded via an adhesive layer to the first
25 side of the carrier layer and at the same time covers the resistance conductor, and wherein the second insulation layer is connected or adhesively bonded via an adhesive layer to the second side of the carrier layer and/or to the heat sink, wherein the second insulation layer covers the heat sink (apart from part of the connection elements). The two insulation layers in particular can each form an outermost top layer of the resistor.

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In accordance with one exemplary resistor, the connection elements protrude from the resistor between the two insulation layers, such that said connection elements each can be welded or soldered to a further component or a contact.

- 5 There is also disclosed an implantable defibrillator comprising a resistor as herein described.

In one exemplary implantable defibrillator, the resistor is electrically conductively connected to a capacitor.

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A method for producing an electrical resistor comprising the following steps is also disclosed:

- connecting a carrier layer to a metal layer, wherein the metal layer forms a heat sink of the resistor and two connection elements of the resistor,
- 15 - forming a separate through-opening for each of the connection elements, each of said through-openings being associated with the corresponding connection element and extending through the carrier layer towards the associated connection element, and
- applying an electrically conductive material to a first side of the carrier layer so as to form a resistance conductor, such that the resistance conductor extends through the
- 20 corresponding through-opening towards the corresponding connection element and contacts this electrically conductively, whereby an electrically conductive connection is produced between the resistance conductor and the two connection elements.

In one exemplary method, the electrically conductive material in order to form the
25 resistance conductor is applied to the carrier layer by coating the carrier layer with said material.

In one exemplary method, the electrically conductive material in order to form the resistance conductor is applied to the carrier layer by sputter deposition of said material.

In one exemplary method, the electrically conductive material in order to form the resistance conductor is applied to the carrier layer by vapour deposition of said material on the carrier layer.

- 5 The electrically conductive material of the resistance conductor can be one of the following substances or the material can comprise one of the following substances: Ti, Au, Cu, Ni, Pd, Nb, Cr (see also above).

10 In one exemplary method, the carrier layer comprises one of the following substances or consists of one of the following substances: a plastic, a polymer, a polyimide. The carrier layer can be formed in particular as a film.

In one exemplary method, the metal layer comprises one of the following substances or consists of one of the following substances (see also above): Cu, an alloy comprising Cu
15 and Ni; Ni; Nb; Ta; a high-grade steel; an alloy comprising Cu, Ni and Mn; an alloy comprising 55 % by weight Cu, 44 % by weight Ni and 1 % by weight Mn (this alloy is also referred to as constantan).

20 In one exemplary method, the metal layer is formed as a sheet which is adhesively bonded to the carrier layer or film.

In one exemplary method it can also be provided that, for resistance reduction, a metal layer is applied to each region of the resistance conductor that in each through-opening extends as far as the corresponding connection element and electrically contacts it. Each
25 metal layer can be formed by deposition of a conductive material (in particular metal, such as Cu) on the region in question.

In one exemplary method, a first insulation layer is adhesively bonded to the first side of the carrier layer, and therefore the resistance conductor is covered, wherein a second
30 insulation layer is adhesively bonded to a second side of the carrier layer and/or to the metal layer, and therefore the metal layer (apart from a portion of the termination

elements) is covered. The second side of the carrier layer in particular faces away from the first side of the carrier layer.

5 In the method described above a resistance region or resistance conductor is advantageously connected directly to the welding region or the connection elements. A plurality of resistors can be produced here simultaneously/in parallel. In addition, due to the omission of the mixed connection consisting of basic material and connection band, it is possible to dispense with a costly galvanic Ni/Au deposition and a complex welding process. It is hereby in turn possible to dispense with an additional insulation layer and a
10 corresponding insulation test.

The disclosed techniques furthermore advantageously allow the use of various substances or metals as resistance conductors (such as Ti, Au, Cu, Ni, Pd, Pt, Nb, etc.). The use of alternative materials which have an increasing electrical resistance with increasing
15 temperature advantageously ensures adaptive current limitation within the resistance conductor during capacitor discharge of a defibrillator. The current limitation in turn has a favourable effect on the further temperature increase and thus on the stability of the resistance conductor and the surrounding materials.

20 Features and embodiments of the invention will be explained hereinafter, by way of example only, and with reference to the figures, in which:

Fig. 1 shows a schematic sectional illustration of a resistor;

25 Fig. 2 shows a perspective view of a further resistor; and

Fig. 3 shows a schematic sectional illustration of the resistor shown in Figure 2.

Figure 1 shows a schematic sectional illustration of an electrical resistor, in particular for
30 use in an implantable defibrillator.

The resistor 1 comprises a resistance conductor 2, which is mounted on a carrier layer 3, and two connection elements 4, which are electrically conductively connected to the resistance conductor 2. The two connection elements 4 are configured each to be welded (in particular by laser welding) or soldered to an electrical contact in order to electrically
5 contact the resistor 1, and that the resistance conductor 2 has regions 20 each overlapping with a separate one of the connection elements 4, said regions each electrically conductively contacting the corresponding connection element 4. In Figure 1 only one connection element 4 is shown on account of the sectional illustration. The second connection element lies in a plane parallel to the drawing plane and is overlapped
10 identically by a region of the resistance conductor 2.

In order to produce the resistance conductor 2, titanium (Ti) can be deposited on the carrier layer 3, for example by means of a thin-film process. The titanium resistance conductor 2 can overlap here with the connection elements 4, which are each formed as a copper
15 structure, and can thus enable a seamless transition. Alternative materials for the resistance conductor 2 are, for example, Au, Cu, Ni, Pd, Pt, Nb, Cr or combinations of these substances.

Each connection element 4 can be exposed in a region, for example by means of a laser,
20 such that said region can be used as a welded contact or connection band. Each element 4 makes it possible to guide a welded contact seamlessly out of a printed circuit board.

A heat sink 5 in the form of a metal layer (for example Cu) is provided on the second side
25 3b of the carrier layer and is used to absorb heat that is created during an electrical pulse of the defibrillator.

As last production step, the metal structures 2, 20, 4 and 5 on both sides 3a, 3b of the carrier layer 3 can also be provided with insulation or top layers 6a, 6b for insulation, which layers are each connected in an integrally bonded manner to the carrier layer 3 via a
30 corresponding adhesive layer 7a, 7b. The connection elements 4 protrude here between the cover layers 6a, 6b.

Figure 2 in conjunction with Figure 3 shows a further exemplary resistor 1. In this variant a top film 3 is glued onto a metal layer 5 in the form of a metal sheet 5 made of constantan, which top film forms a carrier layer 3. Alternative materials for the metal layer 5 are for example different CuNi compounds, Ni, Nb, Ta, high-grade steel, etc. The metal layer 5 on the one hand is used here as a heat sink, and on the other hand forms weldable connection elements 4. In order to produce a connection between the resistance conductor 2 and the metal layer 5, a separate through-opening 30 is formed in the carrier layer 3 for each connection element 4 (in Figure 3 only one through-opening 30 is shown on the basis of the sectional illustration; the other one is disposed in a plane parallel to the drawing plane), for example by means of a laser. If the material of the resistance conductor 2 (for example titanium) is then deposited on the first side 3a of the carrier layer 3 (for example by sputter deposition or by vapour deposition), regions 20 of the resistance conductor 2 that protrude in each case into corresponding through-openings 30 and contact the connection element 4 or the metal layer 5 exposed there (plated through-hole) are created simultaneously.

In accordance with one embodiment of the present description the carrier layer 3 comprises more than one through-opening 30, wherein additional through-openings can be arranged in planes that are parallel to the plane shown in Figure 3. Additional through-openings can be arranged adjacently to one another, for example beside the through-opening 30 in Figure 3. In one exemplary arrangement, the carrier layer 3 comprises through-openings adjacent to one another. In a preferred embodiment the carrier layer 3 comprises a total of 9 through-openings.

A metal layer 21 (for example made of Cu) can be partially deposited on the titanium of each region 20 of the resistance conductor 2. This reduces the electrical resistance locally and makes it possible for a performance drop to occur only in the region in which the heat can be absorbed by the metal layer 5 or heat sink.

As a last step, the metal structures 2, 20, 21, 4 and 5 can in turn be provided on both sides 3a, 3b of the carrier layer 3 for insulation by means of insulation or cover layers 6a, 6b, which are each connected in an integrally bonded manner to the carrier layer 3 via an

adhesive layer 7a, 7b. The connection elements 4 in turn protrude between the top layers 6a, 6b.

5 In the above-described embodiments the resistance conductor may have a layer thickness in the range of from 250 nm to 750 nm, in particular 500 nm. Furthermore, the carrier layer 3 may in each case have a layer thickness in the range of from 10 μm to 40 μm , in particular 25 μm . Furthermore, the metal layer 5 may in each case have a layer thickness in the range of from 35 μm to 100 μm . Furthermore, each metal layer 21 may have a layer thickness in the range of from 1 μm to 20 μm . Furthermore, the connection elements 4 may
10 each have a layer thickness in the range of from 35 μm to 100 μm . Furthermore, the insulation layers 6a, 6b for example may have a layer thickness of 25 μm . Lastly, the adhesive layers 7a, 7b may have a layer thickness in the range of from 25 μm to 75 μm .

The aforementioned values for the individual layer thicknesses are examples of the
15 invention. Values deviating herefrom may also be possible.

Claims

1. An electrical resistor (1) comprising:
 - a resistance conductor (2), which is applied to a carrier layer (3), and
 - 5 - two connection elements (4), which are electrically conductively connected to the resistance conductor (2),

characterised in that the two connection elements (4) are configured to each be weldable or solderable to an electrical contact, and in that the resistance conductor (2) for each connection element (4) has a region (20) overlapping the corresponding

10 connection element, which region electrically conductively connects the corresponding connection element (4).
2. The electrical resistor according to claim 1, **characterised in that** the resistance conductor (2) is arranged on a first side (3a) of the carrier layer (3), wherein a metal
- 15 layer (5) is arranged on a second side (3b) of the carrier layer (3) facing away from the first side (3a) and forms a heat sink.
3. The electrical resistor according to claim 1 or 2, **characterised in that** the connection elements (4) are arranged on the first side (3a) of the carrier layer (3).
- 20 4. The electrical resistor according to claim 2, **characterised in that** the connection elements (4) form portions of the metal layer (5) and/or in that the connection elements (4) are arranged on the second side (3b) of the carrier layer (3).
- 25 5. The electrical resistor according to claim 1 or 4, **characterised in that** the various regions (20) each form a plated through-hole, wherein said regions (20) each extend through a through-opening (30) in the carrier layer (3) and electrically conductively connect the corresponding connection element (4).
- 30 6. The electrical resistor according to claim 5, **characterised in that** a metal layer (21) is applied to each of the regions (20) for local resistance reduction, such that each

region (20) is arranged between the corresponding metal layer (21) and the corresponding connection element (4).

- 5 7. The electrical resistor according to any one of claims 2 to 6, **characterised in that** the metal layer (5, 4) comprises one of the following substances or consists of one of the following substances: Cu; an alloy comprising Cu and Ni; Ni; Nb; Ta; a high-grade steel; an alloy comprising Cu, Ni and Mn; an alloy comprising 55 % by weight Cu, 44 % by weight Ni and 1 % by weight Mn.
- 10 8. The electrical resistor according to any one of the preceding claims, **characterised in that** the two regions (20) of the resistance conductor are connected to one another via a meandering portion (22) of the resistance conductor (2).
- 15 9. The electrical resistor according to any one of the preceding claims, **characterised in that** the resistance conductor (2) consists of one of the following substances or comprises one of the following substances: Ti, Au, Cu, Ni, Pd, Nb, Cr.
- 20 10. The electrical resistor according to any one of claims 2 to 9, **characterised in that** the resistor (1) has a first and a second insulation layer (6a, 6b), wherein the first insulation layer (6a) is connected via an adhesive layer (7a) to the first side (3a) of the carrier layer (3) and covers the resistance conductor (2), and wherein the second insulation layer (6b) is connected via an adhesive layer (7b) to a second side (3b) of the carrier layer (3) and/or to the metal layer (5), wherein the second insulation layer (6b) covers the metal layer (5) at least in some portions.
- 25 11. The electrical resistor according to claim 10, **characterised in that** the connection elements (4) protrude from the resistor (1) between the two insulation layers (6a, 6b).
- 30 12. An implantable defibrillator comprising an electrical resistor (1) according to any one of claims 1 to 11.

13. A method for producing an electrical resistor (1), comprising the following steps:

- connecting a carrier layer (3) to a metal layer (5), wherein the metal layer forms a heat sink of the resistor and two connection elements (4) of the resistor (1),
- forming a separate through-opening (30) for each of the connection elements (4),
5 each of said through-openings being associated with the corresponding connection element (30) and extending through the carrier layer (3) towards the associated connection element (5), and
- applying an electrically conductive material to a first side (3a) of the carrier layer (3) so as to form a resistance conductor (2), such that the resistance
10 conductor (2) extends through the corresponding through-opening (30) towards the corresponding connection element (4) and contacts this electrically conductively, whereby an electrically conductive connection is produced between the resistance conductor (2) and the two connection elements (4).

15 14. The method according to claim 13, wherein the electrically conductive material in order to form the resistance conductor (2) is applied to the carrier layer (3) by coating the carrier layer (3) with said material.

20 15. The method according to claim 13 or 14, wherein a first insulation layer (6a) is adhesively bonded to the first side (3a) of the carrier layer (3), and therefore the resistance conductor (2) is covered, wherein a second insulation layer (6b) is adhesively bonded to a second side (3b) of the carrier layer (3) pointing away from the first side (3a) and/or to the metal layer (5), and therefore the metal layer (5) is covered at least in some portions.