IMPLANT COMPRISING EMBEDDED CONDUCTOR TRACK AND PRODUCTION METHOD

The disclosure relates to an implant comprising an embedded conductor track and to a production method for an implant.

Background

Implants, such as cardiac pacemakers, usually comprise a housing made of titanium, which surrounds the electronic components of the implant (printed circuit board, battery). At least one feedthrough is formed in the housing to establish electrical contact outside the housing, for example for an electrode connection. Forming the feedthrough in the titanium housing is a complex task.

Document EP 2 714 191 B1 discloses an implant comprising a printed circuit board made of liquid crystal polymer and a housing made of liquid crystal polymer. The printed circuit board is fused to edge regions of the housing so as to achieve a hermetic seal.

Document EP 2 440 025 B1 discloses the use of a heating wire for fusing a substrate to a housing disposed on the substrate.

Summary

Aspects of the invention are defined in the independent claims. Some optional features of the invention are defined in the dependent claims.

Thus, it may be possible to provide improved technologies for an implant. In particular, an electrical contact is to be established in a simple manner with a region outside an implant housing. Furthermore, components of the implant are to be protected against contact with body fluid.

According to one exemplary arrangement, an implant is provided. The implant comprises a substrate and a housing, the housing being disposed on the substrate. An electronic circuit is disposed on the substrate inside the housing. An electronic component is disposed on the substrate outside the housing. The implant moreover comprises a conductor track, wherein the conductor track connects the electronic circuit to the electronic component. The conductor track is embedded into the substrate at least in sections in such a way that at least one section of the conductor track is completely surrounded by the substrate. It is not necessary to form a feedthrough in the housing or in the substrate. The related necessary complex steps are avoided. Furthermore, the embedded section of the conductor track is protected against contact with body fluid.

Another exemplary arrangement relates to a method for creating an implant. The method includes the following steps: disposing an electronic circuit on a substrate, disposing a housing on the substrate in such a way that the electronic circuit is disposed inside the housing, disposing an electronic component on the substrate outside the housing, and establishing a connection between the electronic circuit and the electronic component by way of a conductor track, wherein the conductor track is embedded into the substrate at least in sections in such a way that at least one section of the conductor track is completely surrounded by the substrate.

The housing surrounds an interior space. The electronic circuit is disposed in the interior space of the housing. The electronic component is disposed outside the housing (that is, outside the interior space). The electronic circuit and the electronic component are spatially separated.

The housing can be disposed on the substrate in such a way that the interior space is hermetically sealed. The interior space of the housing can be filled with a gas or a plastic material. Suitable gases are noble gases (such as helium) or other inert gases (such as

FIG. 4 shows a perspective view of a fourth embodiment of the implant;

FIG. 5 shows a perspective view of a fifth embodiment of the implant; and

FIG. 6 shows a perspective view of a sixth embodiment of the implant. The top portion of FIG. 6 shows a preliminary stage of the assembly of the implant. The bottom portion of FIG. 6 shows the assembled implant.

Hereafter, the same reference numerals are used for identical components.

FIG. 1 shows a first embodiment of the implant. The implant comprises a substrate 1 and a first housing 2. The first housing 2 is disposed on the substrate 1 so that an interior space 4 is hermetically sealed with respect to the surrounding area. An first electronic circuit 3 and a battery 17 are disposed inside the first housing 2 (that is, in the interior space 4). The battery 17 is connected to the first electronic circuit 3, supplying it with electric energy. An electronic component 5 is disposed on the substrate 1 outside the first housing 2. The electronic component 5 is connected to the first electronic circuit 3 by way of a conductor track 6. The conductor track 6 is embedded into the substrate 1, so that the conductor track 6 is surrounded by the substrate 1 across the entire length thereof. A first heating element 7 is disposed on the substrate 1. Edges of the first housing 2 are disposed on the first heating element 7. Heating of the first heating element 7 prompts the materials of the substrate 1 and of the first housing 2 to melt in the area around the first heating element 7. After cooling, the first housing 2 is fixedly joined to the substrate 1 (thermal welded joint).

The substrate 1 can be a multi-layer substrate and comprise two layers, for example. The layers of the substrate 1 can be made of LCP. The first housing 2 can likewise be made of LCP. The first electronic circuit 3 can be implemented in the form of a printed circuit assembly. Components of the first electronic circuit 3 can be designed as surface-mounted devices (SMD). The interior space 4 of the first housing 2 can be filled with a gas or a plastic material. The conductor track 6 can be made of a biocompatible material, such as gold or titanium. In the event of mechanical damage to the implant, biocompatible metals are advantageous. As an alternative, the conductor track 6 can be made of copper.

So as to hermetically decouple the first electronic circuit 3 together with the battery 17 from the body fluid, the first housing 2 is placed on the substrate 1. The first housing 2 is joined to the substrate 1 by local fusion of the materials of the two components (such as LCP). In one embodiment, a flexible printed circuit board, to which a heating element is applied at the joining sites, is introduced between the first housing 2 and the substrate 1 (not shown). As an alternative, the first heating element 7 can also be integrated directly into the substrate 1. The first heating element 7 is made, for example, of a thin layer of titanium (for example, 100 nm to 500 nm layer thickness) or of a thin gold layer (for example, 100 nm titanium and 500 nm gold) and is connected to an external power source via a connecting structure (for example, made of copper) outside the first housing 2.

In the case of a multi-layer substrate, the conductor track 6 is situated between two flexible printed circuit boards of the substrate 1, which are each coated with LCP melting at a low temperature, so that the surrounding areas comprising LCP having a low melting point melt completely when the first heating element 7 is heated to temperatures above the melting temperature of the LCP having a low melting point (approximately 250 to 300ºC) and establish a form-locked joint between the first housing 2, the two flexible printed circuit boards of the substrate 1 and the conductor track 6. A metal layer or a thin sheet made of metal can be applied to the opposite side to mechanically reinforce the substrate 1.
In one embodiment, a second housing 8 is attached in the same manner on the opposite side of the substrate 1 (FIG. 2). The two housings can be attached together in one operation. The conductor track 6 should at least extend over a distance of 0.1 mm to 0.3 mm inside fused LCP to establish a sufficient diffusion barrier.

Afterwards, the assembly can be metallized together with the first housing 2 to create a further diffusion barrier. The coating comprising a biocompatible metal (such as palladium, gold, platinum or titanium) can be carried out either chemically or by way of a vacuum process. An additional diffusion barrier is applied by the applied metal layer, which blocks possible diffusion pathways along the boundary layers between the various layers of the substrate 1. A hermetic housing is thus created, which offers long-term stability and is able to remain in the body of a patient for at least the service life of the battery 17.

FIG. 2 shows a second embodiment of the implant. In addition to the embodiment shown in FIG. 1 (where all components are disposed on a first side 21, which is here the top side of the substrate 1), further components, these being a second housing 8 and a second electronic circuit 9, are disposed on a second side 22, which is here the bottom side of the substrate 1. The second electronic circuit 9 is disposed inside the second housing 8 (in an interior space 10 of the second housing 8). The second electronic circuit 9 can be connected to the electronic component 5 by way of a further conductor track embedded into the substrate 1 (not shown). A second heating element 11, to which the second housing 8 is attached on the second side 22 of the substrate 1 by fusion, is disposed on the second side 22 of the substrate 1.

A third embodiment of the implant is shown in FIG. 3. In addition to the embodiment shown in FIG. 2, a third housing 12 and a third electronic circuit 13 are disposed on the first side 21 of the substrate 1. The third electronic circuit 13 is disposed inside the third housing 12 (in an interior space 14 of the third housing 12). The third electronic circuit 13 can be connected to the electronic component 5 by way of a further conductor track embedded into the substrate 1 (not shown). A third heating element 15, to which the third housing 12 is attached on the first side 21 of the substrate 1 by fusion, is disposed on the substrate 1. A flexible region 16 of the substrate 1 is formed between the first housing 2 and the third housing 12.

The embodiment shown in FIG. 4 essentially corresponds to the embodiment according to FIG. 1. The electronic component is implemented in the form of eight electrodes 5a here. A different number of electrodes is likewise possible.

In the embodiment shown in FIG. 5, the electronic component is designed as a combination of electrodes 5a and a sensor 5b.

A further embodiment is shown in FIG. 6. A frame 18 is disposed on the substrate 1 in such a way that the frame 18 surrounds the first electronic circuit 3 and the battery 17. A section of the substrate 1 is folded over, so that the section rests on the frame 18 and forms a cover

20. The frame 18 and the cover 20 form a closed area in which the first electronic circuit 3 and the battery 17 are disposed. Electrodes 5a are disposed on the substrate 1 outside the closed area. A coil 19, which is configured to communicate with an external device, is integrated into the folded-over section (cover 20). The frame 18 can be made of LCP. Electrodes can be disposed both inside and outside the closed area on the second or bottom side of the substrate 1.

The technical teaching disclosed here allows implants, for example implantable pulse generators or monitors, to be produced in a considerably simpler, miniaturized and cost-effective manner.

The features disclosed in the description, the claims and the figures can be relevant for the implementation of embodiments either alone or in any random combination with one another.

List of Reference Numerals

1	substrate
2	first housing
3	first electronic circuit
4	interior space of the first housing
5	electronic component
5a	electrode
5b	sensor
6	conductor track
7	first heating element
8	second housing
9	second electronic circuit
10	interior space of the second housing
11	second heating element
12	third housing
13	third electronic circuit
14	interior space of the third housing
15	third heating element
16	flexible region of the substrate
17	battery
18	frame
19	coil
20	cover
21	first side of the substrate
22	second side of the substrate

Patent claims

1. An implant comprising:
   - a substrate (1);
   - a first housing (2), wherein the first housing (2) is disposed on the substrate (1);
   - an first electronic circuit (3) disposed on the substrate (1) inside the first housing (2);
   - an electronic component (5) disposed on the substrate (1) outside the first housing (2);
   - a conductor track (6), wherein the conductor track (6) connects the first electronic circuit (3) to the electronic component (5);

   wherein the conductor track (6) is embedded into the substrate (1) at least in sections in such a way that at least one section of the conductor track (6) is completely surrounded by the substrate (1).

2. The implant according to claim 1, wherein the conductor track (6) is completely embedded into the substrate (1) in such a way that the conductor track (6) is surrounded by the substrate (1) across the entire length thereof.

3. The implant according to claim 1 or 2, wherein the electronic component (5) is an electrode (5a) or a sensor (5b).

4. The implant according to any one of the preceding claims, wherein multiple electronic components (5, 5a, 5b) are disposed on the substrate (1) outside the first housing (2), the multiple electronic components (5, 5a, 5b) being connected to the first electronic circuit (3) by way of multiple conductor tracks (6), and the multiple conductor tracks (6) being embedded into the substrate (1) at least in sections in such a way that, for each conductor track (6), at least one section of the respective conductor track (6) is completely surrounded by the substrate (1).

5. The implant according to any one of the preceding claims, wherein the substrate (1) is a multi-layer substrate, and at least one section of the conductor track (6) is embedded between two layers of the multi-layer substrate.

6. The implant according to any one of the preceding claims, wherein the substrate (1) is made of a thermoplastic.

7. The implant according to any one of the preceding claims, wherein the first housing (2) is made of a thermoplastic.

8. The implant according to any one of the preceding claims, wherein the substrate (1) and the first housing (2) are made of the same material.

9. The implant according to any one of the preceding claims, wherein a second housing (8) is disposed on the substrate (1), and a second electronic circuit (9) is disposed on the substrate (1) inside the second housing (8).

10. The implant according to claim 9, wherein the first housing (2) comprising the first electronic circuit (3) and the second housing (8) comprising the second electronic circuit (9) are disposed on the same side of the substrate (1).

11. The implant according to claim 10, wherein the first housing (2) and the second housing (8) are disposed at a distance from one another, and the substrate (1) is flexible in a region (16) between the first housing (2) and the second housing (8).

12. The implant according to claim 9, wherein the first housing (2) comprising the first electronic circuit (3) is disposed on a first side (21) of the substrate (1), and the second housing (8) comprising the second electronic circuit (9) is disposed on a second side (22) of the substrate (1), the second side (22) being situated opposite the first side (21).

13. The implant according to any one of the preceding claims, wherein a coil (19) is integrated into the first housing (2).

14. A method for creating an implant, comprising the following steps:
    - disposing an first electronic circuit (3) on a substrate (1);
    - disposing a first housing (2) on the substrate (1) in such a way that the first electronic circuit (3) is disposed inside the first housing (2);
    - disposing an electronic component (5) on the substrate (1) outside the first housing (2); and
    - establishing a connection between the first electronic circuit (3) and the electronic component (5) by way of a conductor track (6),

    wherein the conductor track (6) is embedded into the substrate (1) at least in sections in such a way that at least one section of the conductor track (6) is completely surrounded by the substrate (1).