In general, ~~it is an object~~ embodiments of the present invention seek to at least partly overcome the disadvantages arising from the prior art.

~~It is a further object~~Further, embodiments of the present invention seek to provide a pump device, the materials of which are as biocompatible as possible, as easily processable as possible, as corrosion-resistant as possible, and as permanently connectable to one another as possible.

~~It is a further object~~ Further, embodiments of the present invention seek to provide a pump device which ~~is~~may be designed to be as space-saving as possible.

Furthermore, ~~it is an object~~ embodiments of the present invention seek to provide a pump device being as tension-free as possible, more particularly having a housing or pump housing being as tension-free as possible, and to provide in particular a passage from the pump housing to the remaining part of the pump device being as tension-free as possible.

In addition, ~~it is an object~~ embodiments of the present invention seek to provide a pump device which has, during use, an abrasion of the movable parts and the mountings thereof as low as possible.

Furthermore, ~~it is an object~~ embodiments of the present invention seek to provide a pump housing for a pump device which ~~is~~may be integratable in an as simple and as space-saving manner as possible into other components, for example a component housing of the pump device.

Furthermore, ~~it is an object~~ embodiments of the present invention seek to provide a pump housing for a pump device which can be connected in a hermetically sealed manner to a component housing of the pump device.

Furthermore, ~~it is an object~~ embodiments of the present invention seek to provide a housing or pump housing which ~~is~~may be as free from internal and/or external tensions as possible.

Furthermore, ~~it is an object~~ embodiments of the present invention seek to provide a method which makes it possible to produce a pump housing in a manner being as cost-saving and time-saving manner as possible.

Furthermore, ~~it is an object~~ embodiments of the present invention seek to provide a component housing which ~~is~~may be designed to be as space-saving as possible.

~~It is a further object~~ Further, embodiments of the present invention seek to provide a housing which can be connected in a hermetically sealed manner to other components.

A first ~~object~~aspect of the present invention ~~is~~provides a pump device, comprising:

i. an impeller;

ii. a pump housing which at least partly surrounds an interior region, having an inlet and an outlet,

wherein the impeller is located within the interior region of the pump housing;

wherein the pump housing comprises at least one first subregion and at least one further subregion;

wherein the first subregion comprises a ceramic to an extent of at least 61% by weight, ~~preferably to an extent of at least 70% by weight, or preferably to an extent of at least 90% by weight,~~ based on the total mass of the first subregion,

wherein the further subregion comprises a metal content within a range from 40 to 90% by weight, based on the total mass of the further subregion, a metal,

wherein at least one part of the first subregion and at least one part of the further subregion are connected to one another.

The pump device according to the invention is preferably suitable for introduction into the body of a human or of an animal. The pump device according to the invention is further preferably designed to convey body fluids such as blood, serum, plasma, interstitial fluid, saliva or urine. In particular, preference is given to introducing the pump device according to the invention into the blood circulation of a human or animal in order to convey blood. The introduction of the pump device according to the invention can, for example, involve an implantation into the body, a placement onto the body, or a connection to the body.

The pump housing of the pump device according to the invention can have any shape which a person skilled in the art would select for use in a pump device. The pump housing preferably has at least one wall of the pump housing, referred to hereinafter also as pump housing wall. The at least one wall of the pump housing surrounds the interior region of the pump housing. The pump housing has at least two ends, with at least one inlet being arranged at one end and at least one outlet being arranged at the other end. The interior region of the pump housing is, apart from at the inlet and outlet of the pump housing, completely surrounded by the wall. The

of the pump device according to the invention into said living body. The biocompatibility of the surfaces coming into contact with body fluid contributes to the body suffering no damage upon contact with said surfaces.

~~The~~A second aspect of the present invention further provides a method for producing a pump housing for a pump device, comprising the steps:

a. providing a first material;
b. providing a further material;
c. forming a pump housing precursor, wherein a first subregion of the pump housing is formed from the first material and wherein a further subregion of the pump housing is formed from the further material;
d. treating the pump housing precursor at a temperature of at least 300 °C.

Providing the first material in step a. and the further material in step b. can be done in any desired manner which a person skilled in the art would select for this purpose.

Forming of the pump housing precursor can be done in any desired manner which a person skilled in the art would select for the purpose of forming a first subregion and a further subregion. In a preferred design of the method, step c. comprises a shaping process, preferably selected from the group consisting of a lithographic process, an injection molding process, a machining process, an extrusion process or a combination of at least two thereof.

In a lithographic process, various layers of one or more materials are successively shaped. The lithographic process preferably corresponds to a layer-by-layer screen printing process. In the screen printing process, a screen, consisting of a very dimensionally stable material, such as wood; metal, preferably steel; a ceramic or a plastic, having a selected mesh opening is arranged on the object to receive an overlay or over the object to receive an overlay. The printing composition used for application or overlaying, for example in the form of a paste or a powder, is applied to said screen via a nozzle or from a container and pressed through the mesh openings of the screen using a doctor blade. Owing to a pattern in the screen, it is possible to apply at different sites varying amounts of the printing composition used for application or overlaying. For instance, owing to the geometry and arrangement of the mesh openings, it is possible either to apply a uniform film of the printing composition used for overlaying or to alternate regions having little or no printing composition used for application with regions having much printing composition used for application. Preferably, a uniform film of

housing can serve the purpose of keeping the impeller at its position in the pump housing at least in one direction. In this connection, thickening of the wall thickness can take place either during the production process or after said process. In addition or as an alternative, the pump housing can have constrictions.

~~The~~A third aspect of the present invention further provides a method for producing a pump housing for a pump device, comprising the steps:

a) providing a first material;
b) providing a further material;
c) forming a pump housing precursor, wherein firstly a further subregion of the pump housing is formed from the further material and then a first subregion of the pump housing is formed from the first material and wherein a second further subregion of the pump housing is formed from the further material;
d) treating the pump housing precursor at a temperature of at least 300°C.

Providing the first material in step a) and the further material in step b) can be carried out as before in the above-described method for producing a pump housing.

Forming of the pump housing precursor in step c) can be carried out in any desired manner which a person skilled in the art would select for the purpose of forming a first subregion and a further subregion, with observance of the specified order. Details concerning individual substeps have already been specified in the above-described method.

A pump device according to the invention is obtainable by insertion of an impeller into a pump housing, arrangement of electromagnets with coils around the pump housing, and establishment of a circuit with inclusion of a control device and a power source, for example a battery. Preferably, the pump device according to the invention is surrounded by a component housing and the further subregions of the pump housing are connected to the component housing in a material-fitting manner. This can, for example, be carried out by means of a solder connection along the contact point of pump housing and component housing.

In a preferred design of the method for producing a pump housing, step c. comprises a shaping process preferably selected from the group consisting of a lithographic process, an injection molding process, a machining process, an extrusion process or a combination of at least two thereof. Details concerning the various shaping processes have been described for the above-

krypton or mixtures thereof. It is also preferably possible to successively select combinations of different atmospheres for various time periods.

The pump housing precursor can be treated either in one step or preferably in more than one step. Preferably, the pump housing precursor is treated in a first substep of step d. to a temperature within a range from 301 to 600°C, or preferably within a range from 350 to 550°C, or preferably within a range from 400 to 500°C. Said first substep of treatment step d. can take place over a period within a range from 0.1 to 100 h, preferably within a range from 1 to 50 h, or preferably within a range from 2 to 20 h. Said substep can take place either by introduction of the pump housing precursor from step c. into a preheated atmosphere or by slow stepwise or continuously increased heating of the pump housing precursor. Preferably, the treatment in the first substep of step d. of the pump housing precursor is performed in one step at a temperature within a range from 301 to 600°C.

In a second substep of the treatment from step d., which preferably follows the first substep, the pump housing precursor is preferably heated to a temperature within a range from 800 to 2500°C, or preferably within a range from 1000 to 2000°C, or preferably within a range from 1100 to 1800°C. Said substep, too, can take place either by introduction of the pump housing precursor from the first substep of step d. into a preheated atmosphere or by slow stepwise or continuously increased heating of the pump housing precursor. Preferably, the treatment in the second substep of step d. of the pump housing precursor is performed in one step to a temperature within a range from 800 to 2500°C. The treatment of the pump housing precursor in the second substep is performed over a period within a range from 0.1 to 20 h, preferably within a range from 1 to 12 h, or preferably within a range from 2 to 5 h. As stated above, the shape of the pump housing after the production process is preferably continuous.

The present invention further provides a pump housing for a pump device obtainable by the above-described method according to the invention.

~~The~~A fourth aspect of the present invention further provides a housing which at least partly surrounds an interior region, having a first end and a second end,

wherein the housing has at least one first subregion and at least one further subregion;

wherein the first subregion comprises a ceramic to an extent of at least 61% by weight, based on the total mass of the first subregion,

Claims

1. A pump device ~~(10)~~, comprising:

   i. an impeller ~~(80)~~;

   ii. a pump housing ~~(20)~~ which at least partly surrounds an interior region ~~(50)~~, having an inlet ~~(22)~~ and an outlet ~~(24)~~,

   wherein the impeller ~~(80)~~ is located within the interior region ~~(50)~~ of the pump housing ~~(20)~~;

   wherein the pump housing ~~(20)~~ comprises at least one first subregion ~~(26)~~ and at least one further subregion ~~(28)~~;

   wherein the first subregion ~~(26)~~ comprises a ceramic to an extent of at least 61% by weight, based on the total mass of the first subregion ~~(26)~~,

   wherein the further subregion ~~(28)~~ comprises a metal content within a range from 40 to 90% by weight, based on the total mass of the further subregion ~~(28)~~,

   wherein at least one part of the first subregion ~~(26)~~ and at least one part of the further subregion ~~(28)~~ are connected to one another.

2. The pump device ~~(10)~~ as claimed in claim 1, wherein the pump housing ~~(20)~~ comprises a pipe.

3. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein there is at least one further subregion ~~(28)~~ at the inlet ~~(22)~~ or the outlet ~~(24)~~, or wherein there is one further subregion ~~(28)~~ at both the inlet ~~(22)~~ and the outlet ~~(24)~~.

4. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein the pump housing ~~(20)~~ has a volume within a range from 0.1 cm^3 to 10 cm^3.

5. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein the ceramic of the at least one first subregion ~~(26)~~ is selected from the group consisting of aluminum oxide (Al_2O_3), zirconium dioxide (ZrO_2), a zirconium oxide containing an aluminum oxide (ATZ), an aluminum oxide containing a zirconium oxide (ZTA), a zirconium oxide containing an yttrium (Y-TZP), aluminum nitride (AlN), titanium nitride (TiN), magnesium

oxide (MgO), a piezoceramic, barium (Zr, Ti) oxide, barium (Ce, Ti) oxide and sodium potassium niobate or a mixture of at least two thereof.

6. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein the metal of the at least one further subregion ~~(28)~~ is selected from the group consisting of platinum (Pt), iron (Fe), stainless steel (AISI 304, AISI 316 L), iridium (Ir), niobium (Nb), molybdenum (Mo), tungsten (W), titanium (Ti), cobalt (Co), chromium (Cr), a cobalt-chromium alloy, tantalum (Ta) and zirconium (Zr) or a mixture of at least two thereof.

7. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein the at least one first subregion ~~(26)~~ comprises less than 10% by weight, based on the total mass of the first subregion ~~(26)~~, of metal.

8. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein the at least one first subregion ~~(26)~~ and the at least one further subregion ~~(28)~~ are connected to one another by at least one third subregion ~~(30)~~.

9. The pump device ~~(10)~~ as claimed in the preceding claim, wherein the at least one third subregion ~~(30)~~ has a metal content between the metal content of the first subregion ~~(26)~~ and the metal content of the further subregion ~~(28)~~.

10. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein the pump device is at least partly surrounded by a component housing ~~(40)~~, with at least one part of the at least one further subregion ~~(28)~~ of the pump device ~~(10)~~ being connected to the component housing ~~(40)~~.

11. The pump device ~~(10)~~ as claimed in the preceding claim, wherein the component housing ~~(40)~~ comprises at least 30% by weight, based on the total mass of the component housing ~~(40)~~, of titanium.

12. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein the wall ~~(21)~~ of the pump housing ~~(20)~~ has a magnetic permeability of less than 2 μ.

13. The pump device ~~(10)~~ as claimed in any of the preceding claims, wherein the surface ~~(102)~~ of the at least one first subregion ~~(26)~~ which faces the interior region ~~(50)~~ of the

pump housing (20) has a Vickers hardness of at least 330 HV, preferably at least 350 HV, preferably at least 370 HV.

14. The pump device (10) as claimed in any of the preceding claims, wherein at least the outer surfaces (100) of the component housing (40) and the surface (102) facing the interior region (50) of the pump housing (20) are biocompatible.

15. A method for producing a pump housing (20) for a pump device (10), comprising the steps:
    a. providing a first material (60);
    b. providing a further material (70);
    c. forming a pump housing precursor (90), wherein a first subregion (26) of the pump housing (20) is formed from the first material (60) and wherein a further subregion (28) of the pump housing (20) is formed from the further material (70);
    d. treating the pump housing precursor (90) at a temperature of at least 300°C.

16. A method for producing a pump housing (20) for a pump device (10), comprising the steps:
    a) providing a first material (60);
    b) providing a further material (70);
    c) forming a pump housing precursor (90), wherein firstly a further subregion (28) of the pump housing (20) is formed from the further material (70) and then a first subregion (26) of the pump housing (20) is formed from the first material (60) and wherein a second further subregion (28) of the pump housing (20) is formed from the further material (70);
    d) treating the pump housing precursor (90) at a temperature of at least 300°C.

17. The method as claimed in claim 15 or 16, wherein step c. comprises a shaping process, preferably selected from the group consisting of a lithographic process, an injection molding process, a machining process, an extrusion process or a combination of at least two thereof.

18. A pump housing for a pump device (10) obtainable by a method as claimed in at least one of claims 15 to 17.

19. A housing ~~(20)~~ which at least partly surrounds an interior region ~~(50)~~, having a first end ~~(22)~~ and a second end ~~(24)~~,

wherein the housing ~~(20)~~ has at least one first subregion ~~(26)~~ and at least one further subregion ~~(28)~~;

wherein the first subregion ~~(26)~~ comprises a ceramic to an extent of at least 61% by weight, based on the total mass of the first subregion ~~(26)~~,

wherein the further subregion ~~(28)~~ comprises a metal content within a range from 40 to 90% by weight, based on the total mass of the further subregion ~~(28)~~,

wherein at least one part of the first subregion ~~(26)~~ and at least one part of the further subregion ~~(28)~~ are connected to one another.

20. The housing ~~(20)~~ as claimed in claim 19, wherein a slidable element is located in the housing ~~(20)~~, at least in one part of the housing ~~(20)~~.

21. A pump device ~~(10)~~ comprising at least one housing ~~(20)~~ as claimed in claim 19 or 20, or a pump housing ~~(20)~~ obtainable by a method as claimed in at least one of claims 15 to 17.