



(51) International Patent Classification:

B22F 3/105 (2006.01) B22F 10/50 (2021.01)

B22F 10/20 (2021.01) B33Y 10/00 (2015.01)

B22F 10/28 (2021.01) B33Y 80/00 (2015.01)

B22F 10/364 (2021.01) E03C 1/02 (2006.01)

KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(21) International Application Number:

PCT/JP2020/026812

(22) International Filing Date:

09 July 2020 (09.07.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: LIXIL CORPORATION [JP/JP]; 2-1-1 Ojima, Koto-ku Tokyo, 1368535 (JP).

(72) Inventor: ROMANOWSKI Carsten; Langerfeldstrasse 59, Iserlohn, 58638 (DE).

(74) Agent: MORISHITA Sakaki; 3F, VORT Nakameguro I, 1-8-1 Nakameguro, Meguro-ku Tokyo, 1530061 (JP).

(84) Designated States (unless otherwise indicated, for every kind of regional protection available):

ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

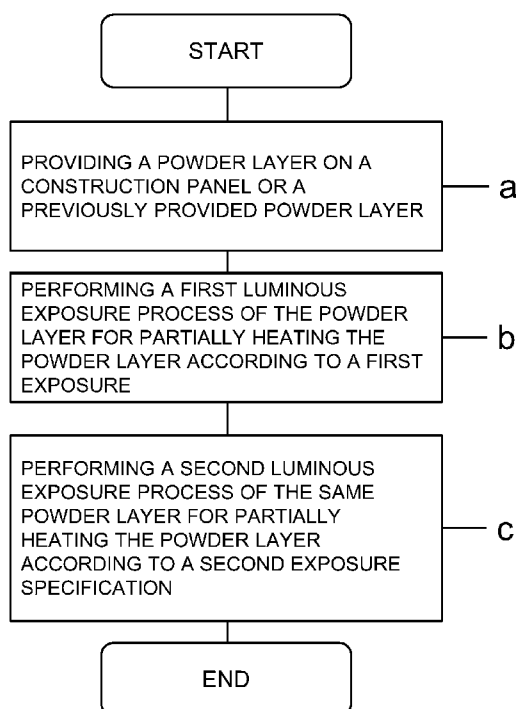
Published:

— with international search report (Art. 21(3))

(81) Designated States (unless otherwise indicated, for every kind of national protection available):

AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN,

(54) Title: METHOD FOR ADDITIVE MANUFACTURE OF COMPONENT



(57) Abstract: The disclosure concerns a method for the additive manufacture of a component (1), comprising: a) Providing a powder layer (2) on a construction panel (3) or a previously provided powder layer (4), b) Performing a first luminous exposure process of the powder layer (2) for partially heating the powder layer (2) according to a first exposure specification (5) which describes at least one three-dimensional partial area of the component (1), and c) Performing a second luminous exposure process of the same powder layer (2) for partially heating the powder layer (2) according to a second exposure specification (6) which describes at least one three-dimensional partial area of the component (1).

Description

Title of Invention: METHOD FOR ADDITIVE MANUFACTURE OF COMPONENT

Technical Field

[0001] The present disclosure concerns a method for the additive manufacture of a component, a system for the additive manufacture of a component, a component for a sanitary fitting and a sanitary fitting. The disclosure may be used in particular for the additive or layered production of (brass) components for sanitary applications.

Background Art

[0002] It is known from the state of the art to manufacture sanitary fittings, such as wash basin fittings, bathtub fittings, concealed fittings or the like from brass. Casting processes are generally used for this purpose in order to be able to realize complex geometries, which may also include different functional elements of the valve.

Summary

[0003] In this connection, however, it could be observed that corresponding casting processes are limited with regard to the quality and accuracy of the geometries and, in particular, their contours that may be achieved with them. This is particularly relevant for particularly thin-walled fittings. In addition, not all freely formable geometries may be realized with appropriate casting processes.

[0004] Additive manufacturing processes are also known in which a component is built up or printed layer by layer. In this context, different approaches to 3D printing of metals have already been proposed. However, 3D printing of metal components for sanitary applications presents some challenges, especially the additive manufacturing of brass components. This is not least due to the requirement to alloy copper and zinc in a certain ratio during additive production or to maintain a corresponding alloy composition of the powder despite reheating. Furthermore, in the case of metal components for sanitary applications, it is often desired to set different material properties in different areas, especially to fulfil different functions. Furthermore, high demands are made on various material or structural properties, which should be as reliable as possible.

[0005] The object of the disclosure is therefore to at least partially solve the problems described with reference to the state of the art and in particular to specify a method for the additive manufacture of a component and a system for the additive manufacture of a component, which enable an adjustment of desired material properties and/or structural properties of the component during the additive manufacture so as to provide improved components for a sanitary fitting as well as sanitary fittings.

[0006] These objects are solved with a method according to the features of the independent claim. Further advantageous features of the disclosure are indicated in the dependent claims. It should be noted that the features individually listed in the dependent claims may be combined in any technologically meaningful way and define further embodiments of the disclosure. In addition, the features indicated in the claims are specified and explained in more detail in the description with further preferred embodiments of the disclosure being presented.

[0007] A method for the additive manufacture of a component that contributes to this, comprises at least the following steps:

- a) Providing a powder layer on a construction panel or a previously provided powder layer,
- b) Performing a first luminous exposure process of the powder layer for partial heating of the powder layer according to a first exposure specification which describes at least one three-dimensional partial area of the component,
- c) Performing a second luminous exposure process of the same powder layer for partial heating of the powder layer according to a second exposure specification which describes at least one three-dimensional partial area of the component.

Brief Description of Drawings

[0008] Fig. 1 illustrates a flow chart of an exemplary sequence of the method described here; Fig. 2 illustrates an additive manufacturing of a component described here according to an example of the method described here in sectional view;

Fig. 3 illustrates an additive manufacturing of a component described here according to a further example of the method described here in sectional view; and

Fig. 4 illustrates an additive manufacturing of a component described here according to another example of the method described here in top view.

Description of Embodiments

[0009] Steps (a) to (c) may, for example, be carried out at least once in the specified order to carry out the method. Furthermore, steps a) to c) may also be repeated (several times) or the method may be started repeatedly (in the manner of a loop) with step a). At least parts of steps a) to c) may be carried out at least partially in parallel or simultaneously. The method may be carried out for the additive manufacture of a component for a sanitary fitting or brass component also described here. Furthermore, the method may be carried out by means of a system also described here.

[0010] In particular, steps b) and c) allow multiple luminous exposure and/or partial luminous exposure of the same powder layer or powder film during additive manufacturing. In particular, the method proposed here allows for the first time that additively built workpieces may be exposed multiple times per powder layer. This con-

tributes in an advantageous way to the fact that (already) during the additive manufacture desired material properties and/or structural properties of the component may be adjusted (especially partially). Especially in manufacturing processes in which an alloy is (only) produced during the additive manufacturing, multiple exposure may help to influence material properties and/or structural properties of the (immediately before) produced alloy already during additive manufacturing in a beneficial way. Alternatively or cumulatively, a partial exposure of the same powder layer with, for example, partially different exposure parameters may help to adjust different material properties and/or microstructure properties in different areas of the component, in particular to fulfil different functions.

[0011] In step a) a powder layer is provided on a construction panel (building board) or a previously provided powder layer. The powder layer may be formed, for example, with a (brass) alloy powder or with a mixture of different metallic powders, such as a mixture comprising a copper powder and a zinc powder. The construction panel may form the base of a powder bed, for example. If the powder layer is formed with a mixture of different, metallic powders, an alloying in a laser beam, for example in the manner of selective laser melting (SLM) or selective laser sintering (SLS), may take place during the first and/or second luminous exposure process.

[0012] In step b) a first luminous exposure process of the powder layer is carried out for partial heating of the powder layer according to a first exposure specification which describes at least a three-dimensional partial area of the component. At least the first luminous exposure process is usually intended to build up the component in an additive or layered manner. Partial heating according to the first exposure process may (thus) be done to a temperature sufficient to cause partial melting of the powder material. In other words, this may also be described in such a way that at least the first luminous exposure process serves the (actual) additive production.

[0013] Additive manufacturing usually involves an additive or layer-wise build-up of the component, which is usually achieved by partial melting of the (metallic) powder material, especially with a laser. The additive or layered construction may also be described in such a way that several layers are formed one after the other, one on top of the other or layer by layer. A layer essentially describes a horizontal cross-section through the component. In partial melting, a powder located within a layer may be heated locally, at predetermined points where material solidification is to occur, for so long and/or so intensively that the metal powder grains there (briefly) liquefy and thus permanently (or until reheated) bond together. Partial melting may be carried out advantageously in the form of 3D printing (in a powder bed) or in the form of a three-dimensional, additive manufacturing process (in a powder bed and/or with laser melting).

- [0014] Furthermore, especially during the first luminous exposure process, it is possible to alloy different metallic powders in a laser beam. Partial heating according to the first exposure process may (thus) be carried out at a temperature sufficient to cause partial fusion of the powder material into an alloy. In particular, it should be possible to form a brass alloy with a mixture of (mixed together) copper powder and zinc powder.
- [0015] In step c) a second luminous exposure process of the same powder layer is carried out for partial heating of the powder layer according to a second exposure specification which describes at least a three-dimensional partial area of the component. For example, the second luminous exposure process may be carried out after the first luminous exposure process (for a specific powder layer) has been completed. The second luminous exposure process may (also) contribute to the additive or layered structure of the component. Partial heating according to the second luminous exposure process may (thus also) be done to a temperature sufficient to cause partial melting of the powder material. If the first and second exposure processes are intended to build up the component in additive or layered form, they may be used to melt different points or areas of the powder layer. In this context, it is advantageous to partially expose individual areas of the component with different parameters. Alternatively or cumulatively, points or areas of the powder layer that were already heated during the first luminous exposure process may be (re)heated during the second luminous exposure process. This may be used, for example, for thermal post-treatment, such as homogenization or re-melting. Especially after alloying in a laser beam, further luminous exposure of the previously alloyed area is advantageous, for example to homogenize or even re-melt the microstructure formed by the alloying. By means of step c), multiple or multi-exposures and/or partial exposures may be achieved by way of example.
- [0016] The first exposure specification and/or the second exposure specification can, for example, each be in the form of a (computer-generated) 3D model or in the form of a 3D data set or each as a 3D exposure target/specification. These 3D models or 3D data sets may contain, for example, location-dependent and/or time-dependent exposure parameters. For example, the exposure specifications may contain location-dependent and/or time-dependent luminous exposure parameters for a number of powder layers or for all powder layers. For example, the first and second (3D) exposure specifications may describe several complementary components or complementary parts of the same component. In this context, for example, the first and second exposure specifications together may represent the desired (final) shape or (final) contour of the component. Alternatively or cumulatively, the first and second exposure specifications can, for example, at least partially (spatially) overlap or overlap each other (and thus together represent the desired (final) shape or (final) contour of the component) or, as an example, each represent the (whole) desired (final) shape or (final) contour of the

component. In the overlapping areas, the different exposure specifications may be used, for example, to create separate or consecutive luminous exposures (so-called multiple exposures) of the same points or areas (in the overlapping area) of the powder layer.

[0017] The (all) exposure specifications are anchored at the same position on the construction panel or relative to the construction panel, so that the exposure specifications may contribute to the description of the same component as easily as possible. In other words, this means in particular that a super-imposed positioning of the exposure specifications (in the manner of at least one "shadow component") and/or a positioning of several complementary components represented by the exposure specifications at (exactly) the same position relative to the construction panel may be carried out. Of course, more than two exposure settings may also be provided, for example to describe more than two complementary components or complementary parts of the same component and/or to be able to carry out more than two multiple exposures. Accordingly, more than two luminous exposure processes may be provided. For example, the number of luminous exposure processes may correspond to the number of exposure specifications.

[0018] For additive manufacturing, the individual (3D) exposure specifications are usually worked-off by exposing the individual powder layers. In particular, the individual (3D) exposure specifications are processed/worked-off one after the other for each powder layer. For example, (all) exposure specifications may be processed/worked-off at least partially in parallel or one after the other with separate laser devices (lasers). Preferably, the (all) exposure specifications (per layer or for each layer) are processed/worked-off one after the other with a common or only one single laser device. In other words, this means in particular that when processing one (each) powder layer, the (all) exposure specifications may be processed one after the other with a common or only one single laser device. As a rule, a new powder layer is only applied after this or after all exposure specifications containing exposure parameters for this powder layer have been processed (this regularly corresponds to a repetition of the procedure in step a)). In particular, the laser or a (3D printing) system set up to carry out the method does not have a component collision check. This contributes in an advantageous way to ensure that the method runs as smoothly as possible even in those areas where the (3D) exposure specifications may overlap (e.g. in the type of shadow components).

[0019] After an advantageous feature, it is suggested that the first exposure specification and the second exposure specification differ in at least one luminous exposure parameter. This allows for partial and/or (overlapping) exposure of individual areas of the component with different parameters (or different values of a parameter) one after the other. The exposure parameters, in which the exposure settings may differ, may

include in particular one or more of the following parameters: Exposure time, exposure intensity, exposure power and/or exposure speed (i.e. speed with which a laser beam moves along a layer). By way of example, exposure power and exposure speed may both either be increased or decreased in subsequent exposure processes. The variation of the luminous exposure parameter may be in the range of at least 5% or at least 10 %. However, the variation of the luminous exposure parameter may not exceed 20% or 30%, for example.

[0020] According to an advantageous embodiment, it is proposed that the first exposure specification includes first luminous exposure parameters for a first partial area of the component and the second exposure specification includes second luminous exposure parameters at least partially different from the first luminous exposure parameters for a second partial area of the component at least partially different from the first partial area. The first exposure parameter and the second exposure parameter may differ, for example, in the value or amount of a certain parameter. For example, a second exposure time may be shorter than a first exposure time. This advantageous design of the method may contribute in an advantageous way to the fact that partially different component characteristics (e.g. densities) may be generated as specifically as possible. Furthermore, this may contribute to the fact that (complementary) for example an outer shell and an inner structure of the component may be printed with different parameters or component characteristics.

[0021] According to an advantageous embodiment, it is proposed that the first exposure specification includes first luminous exposure parameters for at least a first partial area of the component and the second exposure specification includes second luminous exposure parameters for at least a second partial area of the component which at least partially overlaps with the first partial area. This variant of the method may contribute in an advantageous way to multiple exposure of the same point or area of the component, for example for the purpose of thermal aftertreatment of a point or area previously melted in a laser beam for alloying. Also in this context, it may be provided that the first exposure parameters and the second exposure parameters (or their values) differ at least partially from each other. In this context, for example, second exposure intensity may be lower than first exposure intensity.

[0022] According to an advantageous embodiment, it is proposed that during the first luminous exposure process a partial melting of the powder layer and during the second luminous exposure process a thermal aftertreatment (or heat treatment) of at least one region of the powder layer partially melted during the first exposure process is carried out. During the first luminous exposure process, for example, an alloying in a laser beam, such as a copper powder and a zinc powder to form a brass alloy, may take place.

- [0023] In particular, thermal aftertreatment may include at least partial homogenisation of the (brass) structure in the region (partially melted during the first luminous exposure process). In particular, porosity in the microstructure may be reduced or eliminated by a second or subsequent luminous exposure, if possible. Homogenisation usually helps to unify a non-uniform microstructure and/or differences in concentration in the microstructure by means of a (targeted) heat treatment.
- [0024] Alternatively or cumulatively, the thermal aftertreatment may include at least partial re-melting of the microstructure in the region (partially melted during the first luminous exposure process). Thus, for example, re-melting may take place in an already created layer of the component. In particular, inhomogeneous structures may be re-melted over the liquid point of the material so that they may cool down homogenous. Advantageously, areas of higher concentration of one element (in an alloy) may be reduced. Moreover, the melting during the first exposure process may be adapted to allow the formation of an inhomogeneous (micro-)structure and/or an inhomogeneous concentration in the region. In this regard, the thermal aftertreatment during the second exposure process may be adapted to reduce at least part of the/these inhomogeneities by re-melting.
- [0025] According to another aspect, a system for additive manufacturing of a component is proposed, whereby the system is configured to carry out a method described here. The system may include, for example, a powder bed and/or at least one controllable laser device. Furthermore, the system may include, for example, a control unit (controller) that may control the laser device and/or a controllable powder supply to perform the process. For example, the control unit may control the laser device with (three-dimensional) location-dependent and/or time-dependent exposure parameters and/or according to the (3D) exposure specifications.
- [0026] According to another aspect, a component for a sanitary fitting is proposed, whereby the component is manufactured by using a method described here. The component may, for example, form at least one section of a water flow within the sanitary fitting and/or at least part of a housing of the sanitary fitting.
- [0027] According to another aspect, a sanitary fitting (armature) is also proposed, comprising a component described here. The sanitary fitting may be, for example, a washbasin fitting, bathtub fitting or concealed fitting.
- [0028] The details, features and advantageous features discussed in connection with the method may accordingly also occur with the system, component and/or sanitary fitting presented here and vice versa. In this respect, full reference is made to the explanations there concerning the further characterization of the features.
- [0029] The disclosure as well as the technical environment are explained in more detail below using the figures. It should be noted that the figures show particularly preferred

embodiments of the disclosure, but that this is not limited to them. Identical elements in the figures are marked with the same reference signs. It shows schematically:

- [0030] Fig. 1 schematically shows a flow chart of an exemplary sequence of the method described here. The process is used for the additive manufacture of a component 1 (see Figs. 2, 3 and 4). The sequence of steps a), b) and c) is exemplary and may thus be carried out in a regularly operating procedure.
- [0031] In step a), a powder layer 2 is provided on a construction panel 3 or a previously provided powder layer 4 in accordance with step a). In step b), a first luminous exposure process of the powder layer 2 is carried out in accordance with step b) for partial heating of the powder layer 2 in accordance with a first exposure specification 5, which describes at least one three-dimensional partial area of the component 1. In step c), a second luminous exposure process of the same powder layer 2 is carried out according to step c) for partial heating of the powder layer 2 according to a second exposure specification 6, which describes at least a three-dimensional partial area of the component 1.
- [0032] Fig. 2 shows schematically an additive manufacturing of a component 1 described here according to an example of the method described here in sectional view. The reference signs are used consistently, so that reference may be made to the previous explanations.
- [0033] The method may be carried out, for example, by means of a system for additive manufacturing of a component 1. For this purpose, the system may include a laser 10 and a powder bed 11. By means of this process, for example, a component 1 may be produced for a sanitary fitting, whereby component 1 is formed here as an example in the form of a tubular component 1 for water flow in a sanitary fitting.
- [0034] According to the example in Fig. 2, the first exposure target 5 and the second exposure target 6 describe different three-dimensional partial areas/sub-areas 7, 8 of the component 1. The different partial areas 7, 8 are an outer area 7 and an inner area 8 of the exemplary tubular component 1. For example, it may be desirable to specifically set material properties and/or structural properties in the inner area 8 which are particularly advantageous for contact with water, but which are not required or not desired in the outer area 7 of the component 1. In order to realize the different material and/or microstructure properties, the first exposure specification 5 and the second exposure specification 6 may differ, for example, in at least one exposure parameter.
- [0035] Due to the different three-dimensional partial areas 7, 8, the design example according to Fig. 2 is also an example of the fact that and possibly how the first exposure specification 5 may include first luminous exposure parameters for a first partial area 7 of component 1 and the second exposure specification 6 may include second luminous exposure parameters for a second partial area 8 of component 1

which differ at least partially from the first luminous exposure parameters for a second partial area 8 of component 1 which differs at least partially from the first partial area 7.

- [0036] According to the schematic illustration in Fig. 2, it is shown that the exposure specifications 5, 6 may be formed for this purpose, for example, in the form of (computer-generated) 3D models or in the form of 3D data sets. The 3D models or 3D data sets are illustrated in Fig. 2 as examples with dotted lines for the first exposure specification 5 and with dotted lines for the second exposure specification 6. These 3D models or 3D data sets may contain for example location-dependent and/or time-dependent exposure parameters. Furthermore, these (3D) exposure specifications 5, 6 may describe examples of several complementary components or complementary partial areas 7, 8 of the same component 1. For this purpose, it is usually also provided that the exposure specifications 5, 6 are anchored at the same position relative to the construction panel 3.
- [0037] Fig. 3 shows schematically and in a sectional view an additive manufacturing of a component 1 according to a further example. The reference signs are used consistently, so that reference may be made to the previous explanations.
- [0038] Fig. 3 illustrates an example in which the first exposure specification 5 comprises first luminous exposure parameters for at least a first partial area 7 of component 1 and the second exposure specification 6 comprises second luminous exposure parameters for at least a second partial area 8 of component 1 which at least partially overlaps with the first partial area 7. In contrast to the design example according to Fig. 2, Fig. 3 thus shows a superimposed positioning of a "shadow component" at the same position relative to construction panel 3.
- [0039] Fig. 4 shows schematically and in a top view an additive manufacturing of a component 1 according to another example. The reference signs are used consistently, so that reference may be made to the previous explanations. For example, Fig. 4 may show a top view of component 1 from Fig. 3.
- [0040] For example, the overlapping partial areas 7, 8 may be used in an advantageous way so that during the first luminous exposure process a partial melting of the powder layer 2 and during the second exposure process a thermal aftertreatment of at least one region 9 of the powder layer 2 partially melted during the first luminous exposure process may be realized particularly advantageously.
- [0041] In this context, thermal post-treatment may be used, for example, to achieve at least partial homogenisation of the microstructure in region 9 or even at least partial re-melting of the microstructure in region 9.
- [0042] Thus, a method for the additive manufacture of a component, a system for the additive manufacture of a component, a component for a sanitary fitting as well as a

sanitary fitting may be specified, which at least partially solve the problems described with reference to the state of the art and in particular contribute to the fact that desired material properties and/or structural properties of the component may be adjusted during the additive manufacture.

Claims

- [Claim 1] Method for the additive manufacture of a component (1), comprising:
- a) Providing a powder layer (2) on a construction panel (3) or a previously provided powder layer (4);
 - b) Performing a first luminous exposure process of the powder layer (2) for partially heating the powder layer (2) according to a first exposure specification (5) which describes at least one three-dimensional partial area of the component (1); and
 - c) Performing a second luminous exposure process of the same powder layer (2) for partially heating the powder layer (2) according to a second exposure specification (6) which describes at least one three-dimensional partial area of the component (1).
- [Claim 2] The method according to claim 1, wherein the first exposure specification (5) and the second exposure specification (6) differ at least in one luminous exposure parameter.
- [Claim 3] The method according to claim 1 or 2, wherein the first exposure specification (5) comprises first luminous exposure parameters for a first partial area (7) of the component (1) and the second exposure specification (6) comprises second luminous exposure parameters which differ at least partially from the first exposure parameters, for a second partial area (8) of the component (1) which differs at least partially from the first partial area (7).
- [Claim 4] The method according to any one of the preceding claims, wherein the first exposure specification (5) comprises first luminous exposure parameters for at least a first partial area (7) of the component (1) and the second exposure specification (6) comprises second luminous exposure parameters for at least a second partial area (8) of the component (1) at least partially overlapping with the first partial area (7).
- [Claim 5] The method according to any one of the preceding claims, wherein during the first luminous exposure process a partial melting of the powder layer (2) and during the second luminous exposure process a thermal aftertreatment of region (9) of the powder layer (2) partially melted during the first luminous exposure process is carried out.
- [Claim 6] The method according to claim 5, wherein the thermal aftertreatment comprises an at least partial homogenisation of the microstructure in the region (9).
- [Claim 7] The method according to claim 5 or 6, wherein the thermal af-

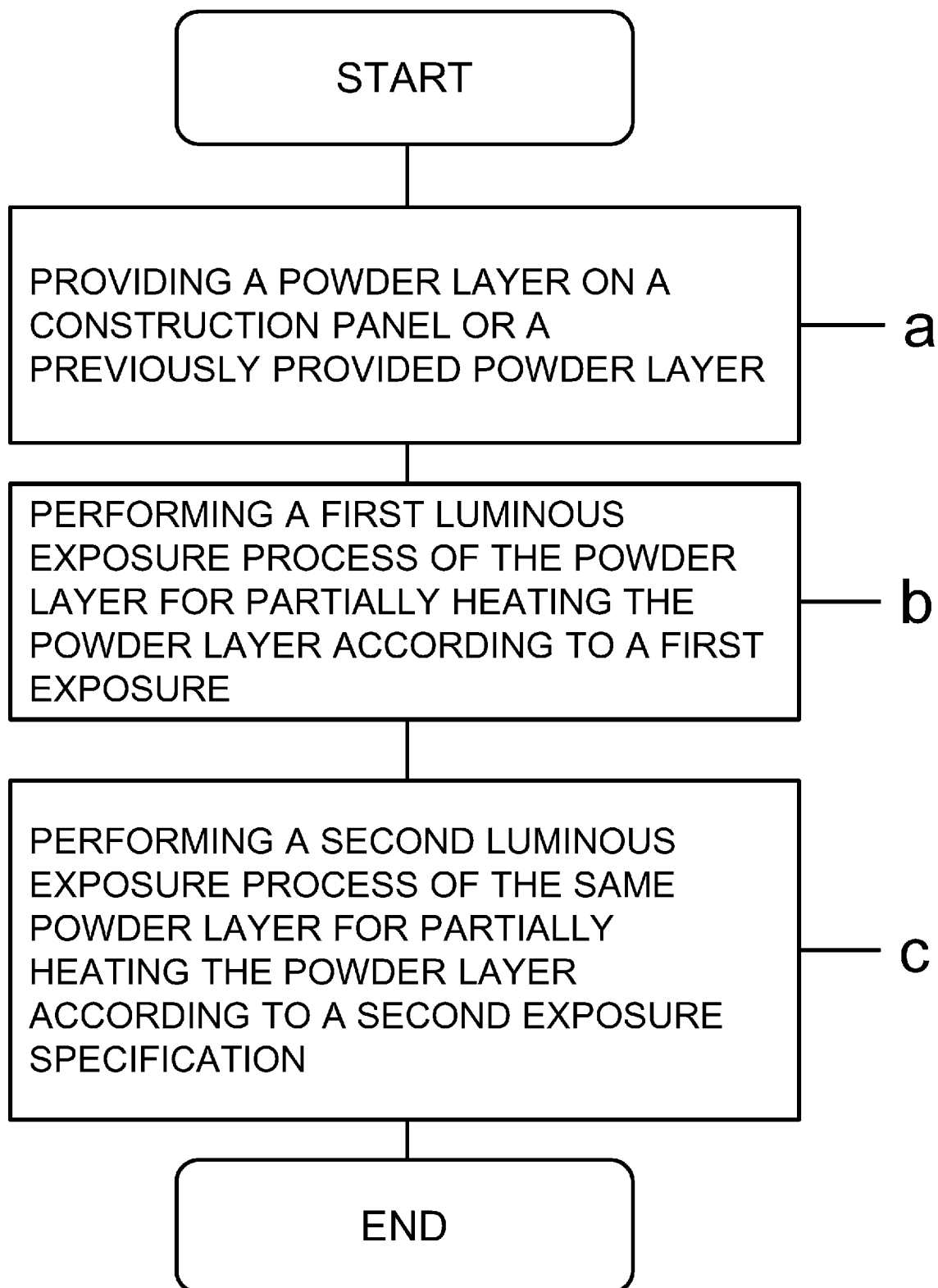
terreatment comprises an at least partial re-melting of the microstructure in the region (9).

[Claim 8] System for the additive manufacture of a component (1), wherein the system is adapted to carry out a method according to any one of claims 1 to 7.

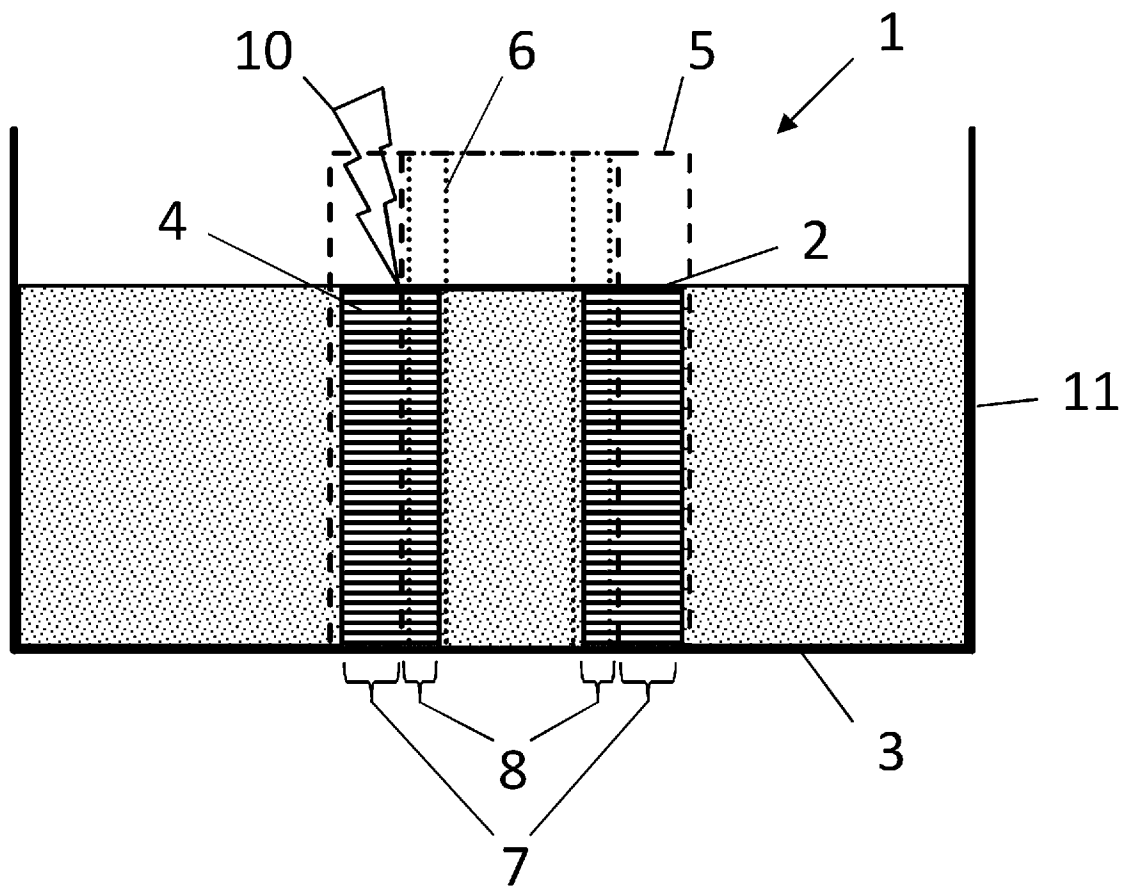
[Claim 9] Component (1) for a sanitary fitting, wherein the component (1) is manufactured by means of a process according to any one of claims 1 to 7.

[Claim 10] Sanitary fitting comprising a component (1) according to claim 9.

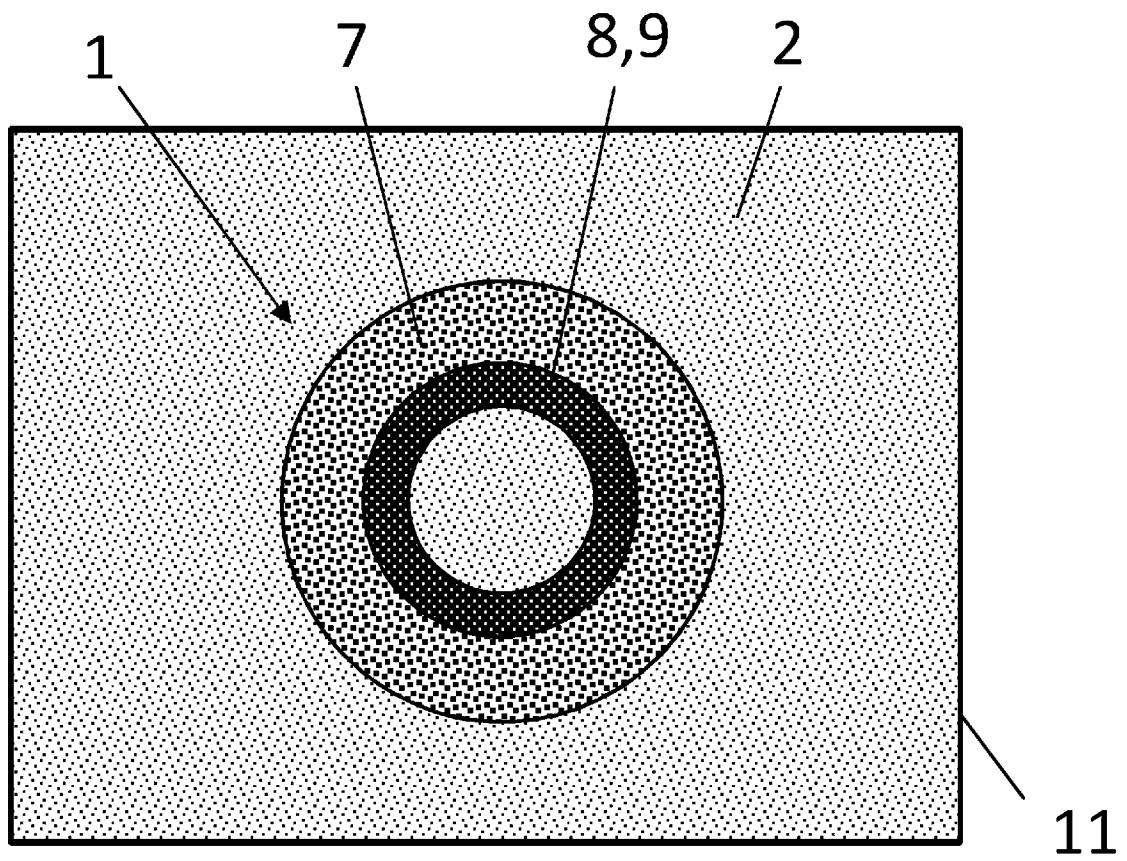
[Fig. 1]



[Fig. 2]



[Fig. 4]



INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2020/026812

A. CLASSIFICATION OF SUBJECT MATTER INV. B22F3/105 B22F10/20 B22F10/28 B22F10/364 B22F10/50 B33Y10/00 B33Y80/00 ADD. E03C1/02		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B22D B22F B33Y E03C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2018/304406 A1 (ROERIG FELIX MARTIN GERHARD [CH] ET AL) 25 October 2018 (2018-10-25) paragraph [0050] paragraph [0025] figures 1,4-8 paragraph [0038] - paragraph [0041] -----	1-8
X	US 2012/211926 A1 (LARSSON MORGAN [SE] ET AL) 23 August 2012 (2012-08-23) paragraph [0056] - paragraph [0057] figures 1,3a,3b,3c -----	1,2,4
X	US 2020/172995 A1 (ROMANOWSKI CARSTEN [DE]) 4 June 2020 (2020-06-04) figure 1 paragraph [0001] - paragraph [0005] ----- -/--	9,10
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 2 March 2021		Date of mailing of the international search report 11/03/2021
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Godino Martinez, M

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2020/026812

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	YI WEI ET AL: "Effect of Deposition Strategy on Fatigue Behavior of Laser Melting Deposition 12CrNi2 Alloy Steel", 2019 IEEE 4TH OPTOELECTRONICS GLOBAL CONFERENCE (OGC), IEEE, 3 September 2019 (2019-09-03), pages 5-8, XP033670650, DOI: 10.1109/OGC.2019.8925011 [retrieved on 2019-12-05] page 6, column 2 abstract -----	6
A	ZHANG XIAO-YAN: "Effect of Laser Surface Remelting on the Corrosion Resistance of 316L Orthodontic Brackets", INTERNATIONAL JOURNAL OF ELECTROCHEMICAL SCIENCE, [Online] 1 April 2016 (2016-04-01), pages 2877-2886, XP055781121, DOI: 10.20964/110402877 Retrieved from the Internet: URL: http://www.electrochemsci.org/abstracts/vol11/110402877.pdf abstract -----	6

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/JP2020/026812

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2018304406	A1	25-10-2018	NONE

US 2012211926	A1	23-08-2012	CN 101479064 A 08-07-2009
		EP 2049289 A1 22-04-2009	
		JP 5108884 B2 26-12-2012	
		JP 2009544501 A 17-12-2009	
		KR 20090049576 A 18-05-2009	
		US 2010007062 A1 14-01-2010	
		US 2012211926 A1 23-08-2012	
		WO 2008013483 A1 31-01-2008	

US 2020172995	A1	04-06-2020	CN 111032893 A 17-04-2020
		CN 111945031 A 17-11-2020	
		DE 102017118386 A1 14-02-2019	
		EP 3665312 A1 17-06-2020	
		JP 2020528965 A 01-10-2020	
		US 2020172995 A1 04-06-2020	
		WO 2019030416 A1 14-02-2019	
