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STATOR FOR A VACUUM PUMP

FIELD OF THE INVENTION

The field of the invention relates to a stator for vacuum pump, a vacuum
5 pump, and a method for forming a stator for vacuum pump.

BACKGROUND

Rotating machines, such as compressors or vacuum pumps, need to be
carefully designed and manufactured in order for the moving parts to cooperate
10 with each other accurately. Providing effective seals to seal the machine tends
to be problematic, particularly when fluid flow is encouraged by a pressure
difference between the machine and ambient environment. It is desired to
provide improved sealing.

15 SUMMARY OF THE INVENTION

In an aspect, there is provided a vacuum pump stator, comprising a first
stator component having a first surface and a second stator component having
a second surface. At least one of the first surface or the second surface
comprises one or more recesses. The first stator component and the second
20 stator component are configured to be sealingly connected to each other with
at least a part of the first surface in abutment with at least a part of the second
surface, thereby to define one or more pumping chambers between the first
stator component and the second stator component, each of the one or more
pumping chambers being defined at least in part by a respective one of the one
25 or more recesses. The first stator component and the second stator component
are formed of a first material. At least a portion of each of the first surface and
the second surface that, when the first stator component and the second stator
component are sealingly connected to each other with the at least a part of the
first surface in abutment with the at least a part of the second surface, at least
30 partially defines the one or more pumping chambers is an unlapped portion

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formed of the first material. At least a portion of each of the first surface and the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not
5 define the one or more pumping chambers is plated in a second material, the second material being different to the first material.

The first material may be spheroidal graphite, SG, iron.

The second material may be nickel-phosphorus (NiP) alloy.

The entirety of the first surface that, when the first stator component and
10 the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers may be an unplated portion formed of the first material.

The entirety of the first surface that, when the first stator component and
15 the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers may be plated in the second material.

The entirety of the second surface that, when the first stator component
20 and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers may be an unplated portion formed of the first material.

The entirety of the second surface that, when the first stator component
25 and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers may be plated in the second material.

The first stator component and the second stator component may
30 comprise respective end portions that, when the first stator component and the

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second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, are arranged to receive a vacuum pump thermal break plate. At least a portion of each of the end portions may be plated in the second material.

- 5 In a further aspect, there is provided a vacuum pump comprising the vacuum pump stator of any preceding claim, wherein the first stator component and the second stator component are sealingly connected to each other with at least a part of the first surface in abutment with at least a part of the second surface, thereby to define the one or more pumping chambers between the first
10 stator component and the second stator component; and one or more rotors arranged to rotate within the one or more pumping chambers.

The vacuum pump may further comprise one or more sealing means disposed between the at least a part of the first surface and the at least a part of the second surface.

- 15 The vacuum pump may comprise one or more vacuum pump thermal break plates, each vacuum pump thermal break plate being sealingly attached to a respective end of the vacuum pump stator.

- In a further aspect, there is provided a method of forming a vacuum pump stator, the method comprising: providing a first stator component having a
20 first surface, the first stator component being formed of a first material; and providing a second stator component having a second surface, the second stator component being formed of the first material; wherein at least one of the first surface or the second surface comprises one or more recesses; the first stator component and the second stator component are configured to be
25 sealingly connected to each other with at least a part of the first surface in abutment with at least a part of the second surface, thereby to define one or more pumping chambers, each of the one or more pumping chambers being defined at least in part by a respective one of the one or more recesses; and the method further comprises: plating, in a second material, at least a portion of
30 each of the first surface and the second surface that, when the first stator component and the second stator component are sealingly connected to each

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other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers, the second material being different to the first material; and maintaining, in an unplated state, at least a portion of each of the first surface and the second
5 surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers.

The maintaining may comprise, during the plating, masking the at least a
10 portion of each of the first surface and the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers.

15 In a further aspect, there is provided a vacuum pump stator, comprising: a first stator component having a first surface; and a second stator component having a second surface; wherein at least one of the first surface or the second surface comprises one or more recesses; the first stator component and the second stator component are configured to be sealingly connected to each
20 other with at least a part of the first surface in abutment with at least a part of the second surface, thereby to define one or more pumping chambers, each of the one or more pumping chambers being defined at least in part by a respective one of the one or more recesses; the first stator component and the second stator component are formed of a first material; the first surface
25 comprises: a first surface portion that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers, the first surface portion being an unplated surface portion formed of the first material;
30 and a second surface portion that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second

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surface, does not define the one or more pumping chambers, the second surface portion being plated in a second material, the second material being different to the first material; and the second surface comprises: a third surface portion that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers, the third surface portion being an unplated surface portion formed of the first material; and a fourth surface portion that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers, the fourth surface portion being plated in the second material.

In a further aspect, there is provided a vacuum pump stator, comprising: a first stator component having a first joining surface; and a second stator component having a second joining surface; wherein the first stator component and the second stator component are formed of a first material; the first joining surface comprises a first sealing portion and a first pumping chamber portion; the second joining surface comprises a second sealing portion and a second pumping chamber portion; the first stator component and the second stator component are configured to be sealingly connected to each other with the first sealing portion being sealed against the second sealing portion, thereby to define one or more pumping chambers, each of the one or more pumping chambers being defined by the first pumping chamber portion and the second pumping chamber portion; the first sealing portion and the second sealing portion are unplated surface portions formed of the first material; and the first pumping chamber portion and the second pumping chamber portion are plated in a second material, the second material being different to the first material.

BRIEF DESCRIPTION OF THE DRAWINGS

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The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration (not to scale) showing a housing of a vacuum pump;

5 Figure 2 is a schematic illustration (not to scale) of the vacuum pump;

Figure 3 is a schematic illustration (not to scale) showing further details of a stator component;

Figures 4 and 5 are schematic illustrations (not to scale) showing further details of a thermal break plate; and

10 Figure 6 is a process flow chart showing certain steps of a method of assembling or providing a vacuum pump stator.

DETAILED DESCRIPTION

Figure 1 is a schematic illustration (not to scale) showing a housing 100 of a vacuum pump, according to one embodiment. The housing 100 comprises a stator comprising a pair of shell stators, hereinafter referred to as the first stator component 101 and the second stator component 102. The housing further comprises a pair of end plates or thermal break plates, hereinafter referred to as the first thermal break plate 103 and the second thermal break plate 104.

The first stator component 101 has a first surface 106 which, in the orientation of Figure 1, is the lower surface of the first stator component 101 facing the second stator component 102. The first surface 106 comprises a plurality of first recesses 108 defined therein.

25 The second stator component 102 has a second surface 110 which, in the orientation of Figure 1, is the upper surface of the second stator component 102 facing the first stator component 101. The second surface 110 comprises a plurality of second recesses 112 defined therein.

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The first recesses 108 and the second recesses 112 defined by the first stator component 101 and the second stator component 102 respectively are configured to receive rotating components, i.e. vacuum pump rotors, of the vacuum pump.

5 The first stator component 101 and the second stator component 102 are brought together (as indicated in Figure 1 by arrows 118, 120) to retain the rotating components in the first and second recesses 108, 112. The thermal break plates 103, 104 are then brought to retain the stator components 101, 102 (as indicated in Figure 1 by arrows 114, 116).

10 Figure 2 is a schematic illustration (not to scale) of the vacuum pump 200 which comprises the housing 100.

 In this embodiment, the first stator component 101 and the second stator component 102 are sealingly connected to each other such that at least a part of the first surface 106 abuts (i.e., contacts) at least a part of the second surface 110. In this embodiment, the first and second recesses 108, 112 are aligned, thereby to define a plurality of pumping chambers 202 between the first stator component 101 and the second stator component 102. The pumping chambers 202 are collectively referred to as a swept volume of the vacuum pump 200. Each of the plurality of pumping chambers 202 is defined at least in part by a
20 respective pair of first and second recesses 108, 112.

 A pair of cooperating rotor assemblies, hereinafter referred to as the first rotor assembly 204 and the second rotor assembly 206, are mounted in the vacuum pump 200. The first rotor assembly 204 comprises a first plurality of vacuum pump rotors 208 mounted to a first shaft 210. The second rotor
25 assembly 206 comprises a second plurality of vacuum pump rotors 212 mounted to a second shaft 214. The first plurality of vacuum pump rotors 208 and the second plurality of vacuum pump rotors 212 are arranged in cooperating pairs of rotors 208, 212. Each pair of cooperating rotors 208, 212 is located within a respective pumping chamber 202.

30 In this embodiment, to adequately seal the first stator component 101 and the second stator component 102 together, one or more (e.g., two)

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longitudinal seals are located along the joining faces (i.e., the first and second surfaces 106, 110) of the stator components 101, 102. Also, to ensure adequate sealing between the stator components 101, 102 and the thermal break plates 103, 104, a pair of seals that define closed shapes (e.g., annular seals in some
5 embodiments) is located between the thermal break plates 103, 104 and the stator components 101, 102. The seals may be elastomer seals.

Figure 3 is a schematic illustration (not to scale) showing further details of the second stator component 102. It will be appreciated by those skilled in the art that the first stator component 101 may have similar or identical
10 construction to the second stator component 102.

The second stator component 102 comprises a body of a first material. The second stator component 102 is formed of the first material, e.g., by one or more processes selected from the group of processes consisting of casting, moulding, machining, and additive manufacturing (AM).

15 In this embodiment, the first material is spheroidal graphite (SG) iron.

The second surface 110, i.e. the joining surface of the second stator component 102 that seals against the first surface 106 of the first stator component 101, defines two portions, hereinafter referred to as the first surface portion 301 and the second surface portion 302.

20 The first surface portion 301 is shown without hatching (i.e., unshaded) in Figure 3. The second surface portion 302 is shown with hatching (i.e., shaded) in Figure 3.

The first surface portion 301 is the portion of the second surface 110 that, when the first stator component 101 and the second stator component 102
25 are sealingly connected to each other (as shown in Figure 2 and described in more detail above) with the first surface 106 positioned against or in abutment with the second surface 110, defines in part the one or more pumping chambers 202. In this embodiment, this first surface portion 301 is defined by the second recesses 112. In other words, the first surface portion 301 is the recessed
30 portion of the second surface 110.

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In this embodiment, the first surface portion 301 is a portion of the second surface 110 that, in use (i.e., when the vacuum pump 200 is in operation), has one or more of the rotor assemblies 204, 206 moving over or across it. The first surface portion 301 is a portion of the second surface 110 that, in use (i.e., when the vacuum pump 200 is in operation), tends to be exposed to a relatively high flow or flow rate of the process gas that is being pumped by the vacuum pump 200.

In this embodiment, the first surface portion 301 is an unplated portion of the second surface 110. In other words, no material plating has been applied to the first surface portion 301. Thus, the first surface portion 301 is a surface formed of the first material, which in this embodiment is SG iron.

The second surface portion 302 is the portion of the second surface 110 that, when the first stator component 101 and the second stator component 102 are sealingly connected to each other (as shown in Figure 2 and described in more detail above) with the first surface 106 positioned against or in abutment with the second surface 110, does not define the one or more pumping chambers 202. In this embodiment, this second surface portion 302 is the part of the second surface that joins to, i.e. may be positioned against and may be in abutment or sealing connection within, the corresponding portion of the first surface 106. In other words, the second surface portion 302 may be a portion of the second surface 110 that is not the second recesses 112.

In this embodiment, the second surface portion 302 is a portion of the second surface 110 that, in use (i.e., when the vacuum pump 200 is in operation), does not have either of the rotor assemblies 204, 206 moving over or across it. The second surface portion 302 is a portion of the second surface 110 that, in use (i.e., when the vacuum pump 200 is in operation), tends either not to be exposed to the process gas, or be exposed to only stagnant or a relatively slow flow or flow rate of the process gas.

In this embodiment, the second surface portion 302 is a plated portion of the second surface 110. In other words, the second portion 302 has been plated in a second material that is different to the first material.

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In this embodiment, one or more grooves on the second surface portion 302 for receiving longitudinal seals for sealing the joining faces (i.e., the first and second surfaces 106, 110) of the stator components 101, 102 may be coated with the second material.

5 In this embodiment, end portions 304 of the second stator component 102, i.e. the end surfaces against which, in use, thermal break plates 103, 104 are positioned, may also be plated with the second material. The end portions 304 define surfaces that do not define the one or more pumping chambers 202. Also, in use (i.e., when the vacuum pump 200 is in operation), the end portions
10 304 do not have either of the rotor assemblies 204, 206 moving over or across them. In use (i.e., when the vacuum pump 200 is in operation), the end portions 304 tend either not to be exposed to the process gas, or be exposed to only stagnant or a relatively slow flow or flow rate of the process gas.

In this embodiment, external surfaces 306 of the second stator
15 component 102, with respect to the pumping chambers 202, may also be plated with the second material. The external surfaces 306 define surfaces that do not define the one or more pumping chambers 202. Also, in use (i.e., when the vacuum pump 200 is in operation), the external surfaces 306 do not have either of the rotor assemblies 204, 206 moving over or across them. In use (i.e., when
20 the vacuum pump 200 is in operation), the external surfaces 306 tend either not to be exposed to the process gas, or be exposed to only stagnant or a relatively slow flow or flow rate of the process gas.

In this embodiment, the second material with which the second portion 302 has been plated is a nickel-phosphorus (NiP) alloy. Electroless NiP plating
25 may be applied. The thickness of the plating that is applied to the second portion may be application dependent, and may, for example, be in the range about 10 μm to about 100 μm , or more preferably about 10 μm to about 50 μm , or more preferably about 10 μm to about 30 μm . More preferably, the thickness of the plating is about 25 μm .

30 It will be appreciated by those skilled in the art that the first stator component 101 has a structure corresponding to that described above for the

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second stator component 102. The first stator component 101 may be similar or identical to the second stator component 102.

More specifically, similar to the second surface 110, the first surface 106 defines two portions.

5 A first surface portion of the first surface 106 is the portion that, when the first stator component 101 and the second stator component 102 are sealingly connected to each other (as shown in Figure 2 and described in more detail above) with the first surface 106 positioned against or in abutment with the second surface 110, defines in part the one or more pumping chambers 202. In
10 this embodiment, this first surface portion is defined by the first recesses 108.

In this embodiment, the first surface portion of the first surface 106 is a portion that, in use (i.e., when the vacuum pump 200 is in operation), has one or more of the rotor assemblies 204, 206 moving over or across it. The first surface portion of the first surface 106 is a portion that, in use (i.e., when the
15 vacuum pump 200 is in operation), tends to be exposed to a relatively high flow or flow rate of the process gas that is being pumped by the vacuum pump 200.

In this embodiment, the first surface portion of the first surface 106 is an unplated portion. In other words, no material plating has been applied to the first surface portion of the first surface 106. Thus, the first surface portion of the first
20 surface 106 is a surface formed of the first material, which in this embodiment is SG iron.

A second surface portion of the first surface 106 is the portion that, when the first stator component 101 and the second stator component 102 are sealingly connected to each other (as shown in Figure 2 and described in more
25 detail above) with the first surface 106 positioned against or in abutment with the second surface 110, does not define the one or more pumping chambers 202. In this embodiment, this second surface portion of the first surface 106 is the part that joins to, i.e. may be positioned against and may be in abutment or sealing connection within, the corresponding portion of the second surface 110.
30 In other words, the second surface portion of the first surface 106 may be a portion that is not the first recesses 108.

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In this embodiment, the second surface portion of the first surface 106 is a portion that, in use (i.e., when the vacuum pump 200 is in operation), does not have either of the rotor assemblies 204, 206 moving over or across it. The second surface portion of the first surface 106 is a portion that, in use (i.e.,
5 when the vacuum pump 200 is in operation), tends either not to be exposed to the process gas, or be exposed to only stagnant or a relatively slow flow or flow rate of the process gas.

In this embodiment, the second surface portion of the first surface 106 is a plated portion. In other words, the second portion of the first surface 106 has
10 been plated in the second material, in a similar or identical way to the second surface portion 302 of the second surface 110. In this embodiment, one or more grooves on the second surface portion of the first surface 106 for receiving longitudinal seals for sealing the joining faces (i.e., the first and second surfaces 106, 110) of the stator components 101, 102 may be coated with the second
15 material.

Figure 4 is a schematic illustration (not to scale) showing further details of the first thermal break plate 103. It will be appreciated by those skilled in the art that the second thermal break plate 104 may have similar or identical construction to the first thermal break plate 103.

20 The first thermal break plate 103 comprises a body of a first material. The first thermal break plate 103 is formed of the first material, e.g., by one or more processes selected from the group of processes consisting of casting, moulding, machining, and additive manufacturing.

The first thermal break plate 103 comprises a joining surface 400 that, in
25 use, may be coupled to a headplate of the vacuum pump. In this embodiment, the joining surface 400 defines two portions, hereinafter referred to as the first surface portion 401 and the second surface portion 402.

The first surface portion 401 is shown without hatching (i.e., unshaded) in Figure 4. The second surface portion 402 is shown with hatching (i.e., shaded)
30 in Figure 4.

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The first surface portion 401 is the portion of the joining surface 400 that, in use (i.e., when the vacuum pump 200 is in operation), may have one or more moving parts of the vacuum pump moving over or across it.

In this embodiment, the first surface portion 401 is an unplated portion of the joining surface 400. In other words, no material plating has been applied to the first surface portion 401. Thus, the first surface portion 401 is a surface formed of the first material, which in this embodiment is SG iron.

The second surface portion 402 is the portion of the joining surface 400 that, in use (i.e., when the vacuum pump 200 is in operation), does not have moving parts of the vacuum pump moving over or across it. The second surface portion 402 is a portion of the joining surface 400 that, in use (i.e., when the vacuum pump 200 is in operation), tends either not to be exposed to the process gas, or be exposed to only stagnant or a relatively slow flow or flow rate of the process gas.

In this embodiment, the second surface portion 402 is a plated portion of the joining surface 400. In other words, the second portion 402 has been plated in the second material, which in this embodiment is a NiP alloy.

In this embodiment, one or more grooves 404 on the second surface portion 402 for receiving closed-shape seals for sealing the joining surface 400 to a headplate may be coated with the second material.

Figure 5 is a schematic illustration (not to scale) showing yet further details of the first thermal break plate 103. Specifically, Figure 5 shows the opposite side of the first thermal break plate 103 to that shown in Figure 4 and described in more detail above.

The first thermal break plate 103 comprises a joining surface 500 that seals against an end of the stator formed from the first and second stator components 101, 102. In this embodiment, the joining surface 500 defines two portions, hereinafter referred to as the first surface portion 501 and the second surface portion 502.

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The first surface portion 501 is shown without hatching (i.e., unshaded) in Figure 5. The second surface portion 502 is shown with hatching (i.e., shaded) in Figure 5.

The first surface portion 501 is the portion of the joining surface 500 that, in use (i.e. when the vacuum pump 200 is in operation), has one or more of the rotor assemblies 204, 206 moving over or across it. In particular, in this embodiment, rotors 208, 212 may move over the first surface portion 501.

In this embodiment, the first surface portion 501 is an unplated portion of the joining surface 500. In other words, no material plating has been applied to the first surface portion 501. Thus, the first surface portion 501 is a surface formed of the first material, which in this embodiment is SG iron.

The second surface portion 502 is the portion of the joining surface 500 that, in use (i.e., when the vacuum pump 200 is in operation), does not have moving parts of the vacuum pump moving over or across it. The second surface portion 502 is a portion of the joining surface 500 that, in use (i.e., when the vacuum pump 200 is in operation), tends either not to be exposed to the process gas, or be exposed to only stagnant or a relatively slow flow or flow rate of the process gas.

In this embodiment, the second surface portion 502 is a plated portion of the joining surface 500. In other words, the second portion 502 has been plated in the second material, which in this embodiment is a NiP alloy.

In some embodiments, the joining surface 500 may comprise one or more grooves for receiving closed-shape seals for sealing the joining surface 500 to an end surfaces of the stator components 101, 102. These grooves may be coated with the second material.

Figure 6 is a process flow chart showing certain steps of a method 600 of assembling or providing a vacuum pump stator, such as that described in more detail earlier above with reference to Figure 2.

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At step s601, the first stator component 101 is provided. The first stator component 101 has a first surface 106. A body of the first stator component 106 is formed of a first material, such as SG iron.

At step s602, the second stator component 102 is provided. The second stator component 102 has a second surface 110. A body of the second stator component 102 is formed of the first material.

At least one of the first surface or the second surface comprises one or more recesses. For example, the first and second surfaces 106, 110 may comprises respective pluralities of recesses, i.e. the first recesses 108 and the second recesses 112.

The first stator component 101 and the second stator component 102 are configured to be sealingly connected to each other with at least a part of the first surface 106 in abutment with at least a part of the second surface 110, thereby to define the one or more pumping chambers 202. Each of the one or more pumping chambers 202 is defined at least in part by a respective one of the one or more recesses, e.g. by respective pairs of first and second recesses 108, 112.

At s603, respective portions of each of the first surface 106 and the second surface 110 that, when the first stator component 101 and the second stator component 102 are sealingly connected to each other with the at least a part of the first surface 106 in abutment with the at least a part of the second surface 110, do not define the one or more pumping chambers 202, are plated in a second material (e.g. NiP alloy). The second material is different to the first material. Any appropriate plating process may be performed.

In some embodiments, the respective portions of each of the first surface 106 and the second surface 110 that are plated in the second material include (e.g., consist of) those portions that are joined together, e.g. are in abutment, when the first stator component 101 and the second stator component 102 are sealingly connected together.

The plating process of step s603 is performed such that respective portions of each of the first surface 106 and the second surface 110 that, when

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the first stator component 101 and the second stator component 102 are sealingly connected to each other with the at least a part of the first surface 106 in abutment with the at least a part of the second surface 110, at least partially define the one or more pumping chambers 202 (e.g. at least the first and second recesses 108, 112) are maintained in an unplated state. Thus, the portions of the first and second surfaces 106, 110, that in use, have the rotor assemblies move over them, are maintained in the unplated state, for example by masking those surface portions during the plating process. In this embodiment, the unplated surface portions are formed of the first material, i.e. SG iron.

Thus, a method 600 of assembling or providing a vacuum pump stator is provided.

The sealing of vacuum pumps, e.g. between the shell stators and between the stator and thermal break plates, tends to be important in achieving good pump performance. In conventional pumps, the performance of the sealing, and hence pump performance, may be reduced by chemical reactions between the stator and/or the sealing gasket and the pumped process gas. The high temperature process gas may cause sealing surfaces (i.e., joining surfaces of SG iron) of the shell stator, for example, to degrade. Advantageously, the plating of the joining surface tends to reduce or eliminate the degradation of the joining surfaces caused by chemical reaction with the pumped process gases. Specifically, the plating with NiP alloy of the abutting portions of the joining surfaces tends to protect, and reduce degradation of, the underlying SG iron surface.

Furthermore, the present inventors have realised that an elastomer seal contacting directly with the SG iron stator may cause iron oxide formation, for example, in high temperature conditions. Such iron oxide formation may cause leakage of gas out of the stator. Advantageously, the NiP plating of the sealing surfaces tends to reduce or eliminate such iron oxide formation.

Mechanical stability tends to be important for vacuum pump efficiency and proper operation. In operation, metal-on-metal contact between rotor and

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stator may occur due to the small clearance therebetween. When such contact does occur, the material property of the contacting surface(s) is an important factor in whether the contact adversely affects pump operation. Chipping, peeling, galling, etc. of the contacting surface(s) may lead to a total breakdown of the machine. Advantageously, the avoidance of plating the surfaces of the stator that define the pumping chambers, i.e. the surfaces that, in use, have the rotor assemblies move across or over them, means the risk of any plating peeling off is eliminated. Also, by not plating such surfaces, the clearance between the stator and the moving rotor assemblies tends to be maintained, or at least not significantly reduced.

If or when, metal-on-metal contact between rotor and stator occurs, the graphite at the surface of the SG iron stator tends to act as a lubricant between the rotor and stator. If such stators surfaces were plated, such a lubrication effect would tend not to occur, which may lead to increased galling, etc., and reduced pumping performance. By avoiding plating the stator in the rotation area/pumping chambers, such lubrication effects tend to be provided.

Furthermore, SG iron used as a substrate for electroless NiP plating may cause porosity in the NiP plating structure. Such porosity of the plating layer may be problematic in fast or turbulent process gas flow areas, such as the pumping chambers, and may lead to increase peeling or galling of the NiP plating in those areas. Advantageously, by avoiding NiP plating of the surfaces of the stator that define the pumping chambers, such effects tend to be reduced or eliminated. Moreover, the present inventors have realised that such porosity of the NiP plating layer in slower/no flow regions of the pump, such as at the sealing surfaces, tends not to be problematic.

Advantageously, the above-described vacuum pump stator tends to provide for both improved sealing and mechanical stability.

In the above embodiments, the vacuum pump is a multi-stage positive displacement pump employing to intermeshing rotors in each of a plurality of pumping chambers. The rotors may have the same type of profile in each

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chamber or the profile may change from chamber to chamber. However, in other embodiments, the vacuum pumping is a different type of vacuum pump.

In the above embodiments, the first surface of the first stator component comprises a plurality of first recesses, and the second surface of the second stator component comprises a plurality of second recesses. Together, the first and second recesses define a plurality of pumping chambers. However, in other embodiments, one or both of the first and second surfaces comprise a different number of recesses to that described above and shown in the Figures. For example, in some embodiments, one or both of the first and second surfaces
5 comprise only a single recess, thereby defining only a single pumping chamber. In some embodiments, the first and second surfaces may comprise a different number of recesses to each other. In some embodiments, one of the first or second surfaces does not comprise any pumping chamber recesses, and the pumping chambers are defined by a flat surface of either of the first or second
10 surfaces and one or more recesses in the other surface.

In the above embodiments, the first material is SG iron. However, in other embodiments, the first material is a different material. Examples of appropriate alternative materials include, but are not limited to, FG (flake graphite) iron, such as flake graphite cast iron, NR (Nickel resist) iron, and
20 aluminium.

In the above embodiments, the first material is a NiP alloy. However, in other embodiments, the second material is a different material and/or has a different structure. An example of an appropriate alternative plating structure is, but is not limited to, a multiple layer plating e.g. comprising NiP and a solid
25 lubricant.

In some embodiments, the entirety of the first surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more
30 pumping chambers is an unplated portion formed of the first material.

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In some embodiments, the entirety of the first surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers is plated in the second material.

In some embodiments, the entirety of the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers is an unplated portion formed of the first material.

In some embodiments, the entirety of the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers is plated in the second material.

Although illustrative embodiments of the invention have been disclosed in detail herein, with reference to the accompanying drawings, it is understood that the invention is not limited to the precise embodiment and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope of the invention as defined by the appended claims and their equivalents.

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Reference numeral list

- 100 – housing
- 101 – first stator component
- 102 – second stator component
- 5 103 – first thermal break plate
- 104 – second thermal break plate
- 106 – first surface
- 108 – first recesses
- 110 – second surface
- 10 112 – second recesses
- 114, 116, 118, 120 – arrows indicating direction of movement
- 200 – vacuum pump
- 202 – pumping chambers
- 204 – first rotor assembly
- 15 206 – second rotor assembly
- 208 – first rotors
- 210 – first shaft
- 212 – second rotors
- 214 – second shaft
- 20 301 – first surface portion
- 302 – second surface portion
- 304 – end portions
- 306 – external surfaces 306
- 400 – joining surface
- 25 401 – first surface portion of joining surface 400

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402 - second surface portion of joining surface 400

404 – sealing groove

500 - joining surface

501 - first surface portion of joining surface 500

5 502 - second surface portion of joining surface 500

600 – method

s601-s603 – method steps

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CLAIMS

1. A vacuum pump stator, comprising:
a first stator component having a first surface; and
a second stator component having a second surface; wherein
5 at least one of the first surface or the second surface comprises one or more recesses;
the first stator component and the second stator component are configured to be sealingly connected to each other with at least a part of the first surface in abutment with at least a part of the second surface, thereby to define
10 one or more pumping chambers between the first stator component and the second stator component, each of the one or more pumping chambers being defined at least in part by a respective one of the one or more recesses;
the first stator component and the second stator component are formed of a first material;
15 at least a portion of each of the first surface and the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers is an unplated portion formed of the
20 first material; and
at least a portion of each of the first surface and the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the
25 one or more pumping chambers is plated in a second material, the second material being different to the first material.
2. The vacuum pump stator of claim 1, wherein the first material is spheroidal graphite, SG, iron.

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3. The vacuum pump stator of any preceding claim, wherein the second material is nickel-phosphorus (NiP) alloy.

5 4. The vacuum pump stator of any preceding claim, wherein the entirety of the first surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers is an unplated portion
10 formed of the first material.

 5. The vacuum pump stator of any preceding claim, wherein the entirety of the first surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part
15 of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers is plated in the second material.

 6. The vacuum pump stator of any preceding claim, wherein the
20 entirety of the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers is an unplated portion formed of the first material.

25

 7. The vacuum pump stator of any preceding claim, wherein the entirety of the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second

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surface, does not define the one or more pumping chambers is plated in the second material.

8. The vacuum pump stator of any preceding claim, wherein:

5 the first stator component and the second stator component comprise respective end portions that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, are arranged to receive a vacuum pump thermal break plate; and

10 at least a portion of each of the end portions is plated in the second material.

9. A vacuum pump comprising:

the vacuum pump stator of any preceding claim, wherein the first
15 stator component and the second stator component are sealingly connected to each other with at least a part of the first surface in abutment with at least a part of the second surface, thereby to define the one or more pumping chambers between the first stator component and the second stator component; and

one or more rotors arranged to rotate within the one or more
20 pumping chambers.

10. The vacuum pump of claim 9, further comprising one or more sealing means disposed between the at least a part of the first surface and the at least a part of the second surface.

25

11. The vacuum pump of claim 9 or 10, wherein:

the vacuum pump stator is in accordance with claim 8; and

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the vacuum pump comprises one or more vacuum pump thermal break plates, each vacuum pump thermal break plate being sealingly attached to a respective end of the vacuum pump stator.

5 12. A method of forming a vacuum pump stator, the method comprising:

 providing a first stator component having a first surface, the first stator component being formed of a first material; and

 providing a second stator component having a second surface,
10 the second stator component being formed of the first material; wherein

 at least one of the first surface or the second surface comprises one or more recesses;

 the first stator component and the second stator component are configured to be sealingly connected to each other with at least a part of the first
15 surface in abutment with at least a part of the second surface, thereby to define one or more pumping chambers, each of the one or more pumping chambers being defined at least in part by a respective one of the one or more recesses; and

 the method further comprises:

20 plating, in a second material, at least a portion of each of the first surface and the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers, the second
25 material being different to the first material; and

 maintaining, in an unplated state, at least a portion of each of the first surface and the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second
30 surface, at least partially defines the one or more pumping chambers.

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13. The method of claim 12, wherein the maintaining comprises, during the plating, masking the at least a portion of each of the first surface and the second surface that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers.

14. A vacuum pump stator, comprising:
a first stator component having a first surface; and
a second stator component having a second surface; wherein
at least one of the first surface or the second surface comprises one or more recesses;

the first stator component and the second stator component are configured to be sealingly connected to each other with at least a part of the first surface in abutment with at least a part of the second surface, thereby to define one or more pumping chambers, each of the one or more pumping chambers being defined at least in part by a respective one of the one or more recesses;

the first stator component and the second stator component are formed of a first material;

the first surface comprises:
a first surface portion that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers, the first surface portion being an unplated surface portion formed of the first material; and

a second surface portion that, when the first stator component and the second stator component are sealingly connected to each

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other with the at least a part of the first surface in abutment with the at least a part of the second surface, does not define the one or more pumping chambers, the second surface portion being plated in a second material, the second material being different to the first material; and

5 the second surface comprises:

a third surface portion that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a part of the second surface, at least partially defines the one or more pumping chambers,
10 the third surface portion being an unplated surface portion formed of the first material; and

a fourth surface portion that, when the first stator component and the second stator component are sealingly connected to each other with the at least a part of the first surface in abutment with the at least a
15 part of the second surface, does not define the one or more pumping chambers, the fourth surface portion being plated in the second material.

15. A vacuum pump stator, comprising:

a first stator component having a first joining surface; and

20 a second stator component having a second joining surface;
wherein

the first stator component and the second stator component are formed of a first material;

the first joining surface comprises a first sealing portion and a first
25 pumping chamber portion;

the second joining surface comprises a second sealing portion and a second pumping chamber portion;

the first stator component and the second stator component are configured to be sealingly connected to each other with the first sealing portion

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being sealed against the second sealing portion, thereby to define one or more pumping chambers, each of the one or more pumping chambers being defined by the first pumping chamber portion and the second pumping chamber portion;

the first sealing portion and the second sealing portion are
5 unplated surface portions formed of the first material; and

the first pumping chamber portion and the second pumping chamber portion are plated in a second material, the second material being different to the first material.