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(54) **A ROTOR FOR A TWIN SHAFT PUMP AND A TWIN SHAFT PUMP**

(57) A ceramic rotor configured for a twin shaft pump and a twin shaft pump comprising such a rotor.

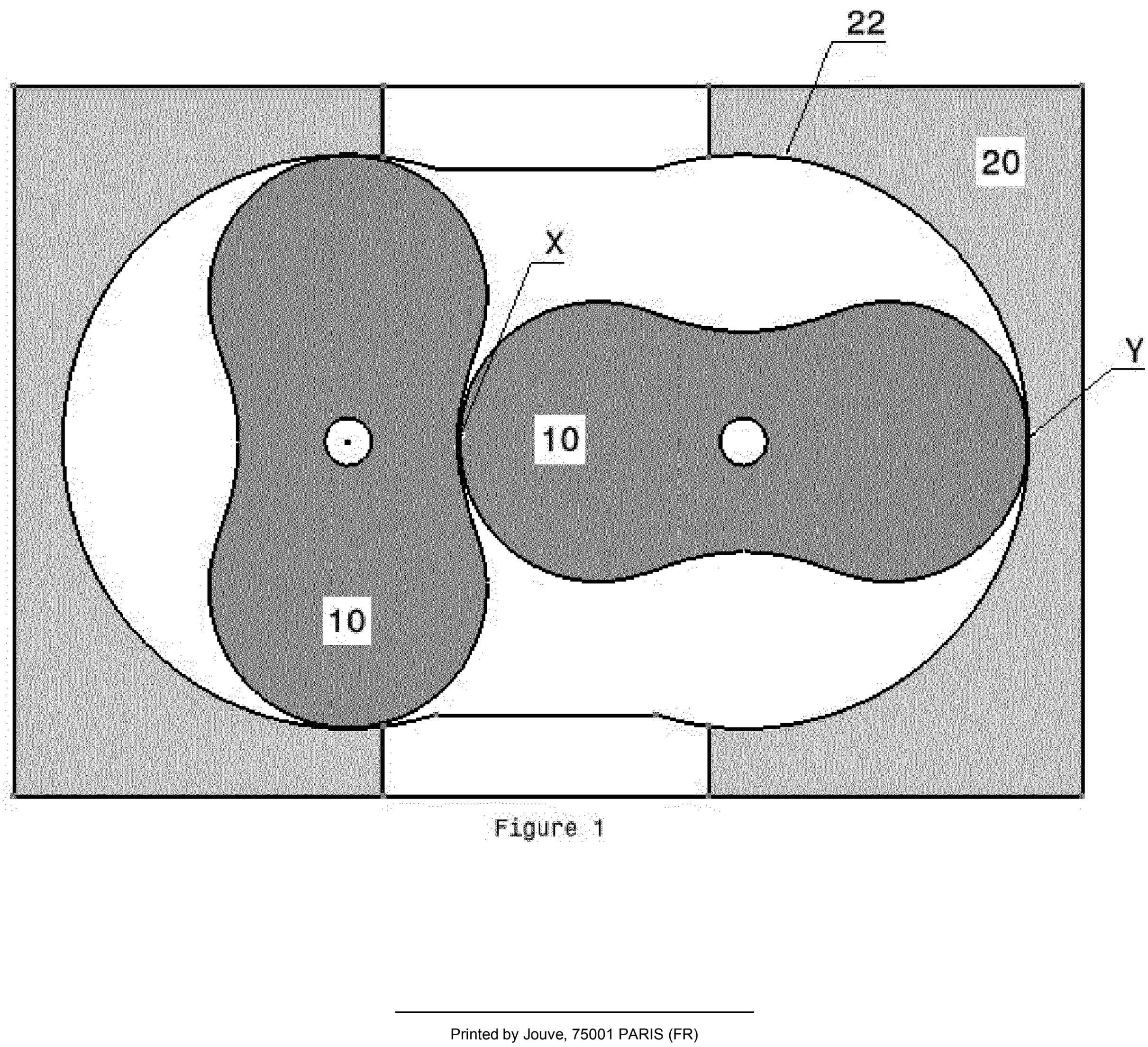

Figure 1

EP 3 653 881 A1

Description

FIELD OF THE INVENTION

[0001] The field of the invention relates to rotors for twin shaft pumps and to twin shaft pumps.

BACKGROUND

[0002] The properties required for rotors of twin shaft pumps depend on the pump's field of operation but may include: hardness which is particularly important where the gas being pumped comprises particulates; chemical resistance where aggressive chemicals are to be pumped; and temperature resistance where the temperature of the pump and/or the gases being pumped is high. Furthermore, low heat transfer properties may be desirable as may a low coefficient of thermal expansion or a similar coefficient of thermal expansion to that of the surrounding materials. In this way clearances, particularly between rotors mounted on twin shafts can be maintained while the temperature of the pump changes during operation.

[0003] Generally rotors have been made of metal materials as these are relatively simple to manufacture into required forms using casting and standard industrial machining techniques, for example. A metal is a relatively hard material, may operate at relatively high temperatures and may be corrosion resistant or may be treated to improve corrosion resistance. The treatment of such metal materials to improve corrosion resistance may include coating. The coating itself may lead to problems particularly during high temperature operation and/or operation in high particulate environments where the coating may become damaged and the rotor susceptible to wear.

[0004] It would be desirable to provide a rotor that was suitable for twin shaft pumps and that was both hard, chemically resistant and thermally stable.

SUMMARY

[0005] A first aspect provides a ceramic rotor configured for a twin shaft pump. Twin shaft pumps, particularly those used as dry backing pumps in semiconductor processes are required to be hard, resistant to chemicals, in particular fluorine based gases and preferably suitable for high temperature operation.

[0006] Ceramics are known to be particularly hard materials that can have a low thermal conductivity and are suitable for high temperature operation. However, they have not conventionally been used as rotors in twin shaft pumps as they are both difficult and expensive to manufacture and their corrosion resistance and robustness is not proven in such situations. The failure of a rotor in such a system can cause significant damage to the pump and result in costly process downtime.

[0007] The inventor of the present invention determined that despite these technical prejudices, modern ceramics are chemically resistant to a sufficient level for pumping chemically aggressive gases such as fluorine, and that even were such a rotor to fail then the nature of ceramics is such that the failed rotor would be contained within a metal stator. Furthermore, their thermal coefficient of expansion which is similar to that of the materials supporting the shafts makes them particularly advantageous for twin shaft operation where the clearances between the rotors should be maintained across a temperature range. Thus, they determined that despite the technical prejudices, a ceramic rotor would be suitable for a twin shaft pump and would have many advantages.

[0008] In some embodiments, said twin shaft pump is configured for operation in semiconductor processing, in a high particulate and chemically aggressive environment.

[0009] Twin shaft pumps may be used in semiconductor processing or DSL applications, in particular as backing or booster pumps for turbo molecular pumps.

[0010] Semiconductor processing involves process gases flowing through the chamber which gases may be full of particulate. Semiconductor processing also involves cleaning gases flowing through the chambers to clean the chambers. These gases are chemically very aggressive. Thus, vacuum pumps used in semiconductor processing applications are required to be both resistant to particulates and to chemically aggressive substances. In order for a pump to be resistant to particulates, the constituent parts and in particular the rotors should be formed of a material that is very hard. This hard material must also be resistant to any chemicals used during the cleaning cycle. A drawback of a particularly hard rotor is that it is difficult to machine. In this regard, prior to mounting within a twin shaft pump rotors need to be balanced and ground such that the when mounted in the pump the clearances between the rotors and between the rotors and stator, which clearances dictate the efficiency of the pump and its robustness, are provided to suitably high tolerances. Grinding a particularly hard material is difficult and in the case of ceramics requires diamond tools to perform the grinding. However, the advantages of ceramic materials in the manufacture of such rotors and in particular, their hardness and their unexpected resistance to chemicals particularly to fluorine based gases means that the elevated costs associated with their manufacture are more than compensated for by a substantial increase in the lifetime of the pump at least for some applications. Thus, for applications such as semiconducting processing a twin shaft pump with ceramic rotors is particularly advantageous.

[0011] Although the rotor may be made from a number of different ceramics in some embodiments, said rotor comprises a Zirconia Toughened Alumina type ceramic (ZTA)

[0012] Zircona Toughened Alumina (ZTA) has been found to be sufficiently hard and sufficiently resistant to fluorine to make it suitable for rotors of a pump used for semiconductor processing applications while being a material that can be manufactured and ground to the required shape and tolerances.

[0013] In some embodiments, said rotor comprises a rotor for a Roots-type pump.

[0014] A rotor for a Roots type pump is relatively easy to balance and to manufacture to have the required clearances and as such the grinding step is less onerous than some rotor designs making a Roots type pump particularly applicable for a ceramic rotor.

[0015] In other embodiments, said rotor comprises a rotor for a Northey-type pump. A Northey-type or hook and claw rotor may also be formed from ceramics.

[0016] In still other embodiments, said rotor comprises a screw rotor for a twin-shaft screw pump.

[0017] In some embodiments, said ceramic rotor is configured for operation above a temperature of 150°C. In other embodiments, said ceramic rotor is configured for operation between 100°C and 300°C.

[0018] The nature of the ceramic material forming the rotor makes it suitable for use at high temperatures. In particular it is thermally resistant, coping with high temperatures, and its thermal coefficient of expansion is low and may be similar to the material that supports the twin shafts and thus, any thermal expansion of the rotors substantially matches that of the shaft separation allowing clearances to be maintained across a temperature range.

[0019] A second aspect provides a twin shaft pump comprising a pair of ceramic rotors according to a first aspect.

[0020] In some embodiments, the twin shaft pump comprises a dry pump. Dry pumps are often used in semiconductor processing where it is important that the processing chambers are kept clean and free from contaminants. With a dry pump the clearances are key to providing efficient pumping thus, forming a rotor of a substance with suitable thermal expansion properties and which is sufficiently hard to tolerate pumping a dusty gas makes a particularly effective rotor for a dry pump.

[0021] In some embodiments said twin shaft pump comprises a ceramic lined stator.

[0022] The use of a ceramic rotor may extend the lifetime of a pump operating in a corrosive environment. However, in such an environment the stator may also be prone to corrosion and where the rotor is a ceramic rotor the stator may then become the limiting factor for the lifetime of the pump. Providing a ceramic liner to the stator of such a pump will increase its resistance to corrosive and dusty environments, while the outer metal casing provides protection were the rotor to fail.

[0023] In some embodiments, said pump is configured to operate as one of a backing or booster pump in semiconductor processing.

[0024] As noted previously, the rotor is particularly applicable in semiconducting processing as a backing or booster pump. Chemical wear is particularly a problem at the exhaust end of a backing pump and thus, providing a backing pump with a ceramic rotor may increase its lifetime significantly and as such provide a significant advantage that more than compensates for any increase in initial costs.

[0025] In some embodiments, said twin shaft pump is configured for pumping both chemically aggressive and dusty gases.

[0026] In some embodiments, said chemically aggressive gas comprises a fluorine based gas, such as F_2, NF_3, F or ClF_3.

[0027] As mentioned previously ceramics are both chemically resistant and hard. They have been found to be particularly resistant to fluorine based gases which gases are used commonly in the cleaning cycles of a semiconductor processing system and which causes significant wear and performance loss on the rotors of conventional twin shaft pumps. Providing such pumps with ceramic rotors may significantly increase the lifetime and performance of the pump.

[0028] Further particular and preferred aspects are set out in the accompanying independent and dependent claims. Features of the dependent claims may be combined with features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

[0029] Where an apparatus feature is described as being operable to provide a function, it will be appreciated that this includes an apparatus feature which provides that function or which is adapted or configured to provide that function.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Embodiments of the present invention will now be described further, with reference to the accompanying drawings, in which:

Figure 1 shows a twin shaft pump comprising ceramic rotors according to an embodiment.

DESCRIPTION OF THE EMBODIMENTS

[0031] Before discussing the embodiments in any more detail, first an overview will be provided.

[0032] Tests have demonstrated a ceramic's resistance to high partial pressures of aggressive semiconductor cleaning gasses (for example 20% F_2 at 250°C for in excess of 1200Hrs). The use of a specific, but commercially available, ceramic material as a rotor in a dry pump, and in particular, in a twin shaft dry pump has been shown to be feasible. The test results reveal a material lifetime capability, commensurate with typical pump service intervals for process applications, where large quantities of hard dusty process by-product are generated and where there is a subsequent aggressive cleaning cycle; the deployment of ceramic materials in the dry pump mechanism, effectively addresses the issue of 'chemical wear', that materials (which are either hard or chemically resistant, but not both) normally used in dry pumps, are subject to.

[0033] There are certain Semicon and DSL applications where aspects of the process cycle require materials with extreme hardness, in order to cope with abrasive by-product and chemical resistance, in order to cope with aggressive cleans. Whilst there are materials which have one or other of these properties, there are few that have both. In particular, whilst the hardness of ceramic materials is known and whilst there was speculation that certain ceramic materials had a reasonable degree of Fluorine resistance, the extent of that chemical robustness (in terms of lifetime at partial pressure and temperature) was not established.

[0034] However, specific tests undertaken to ascertain the limits have shown that it would be worthwhile making rotors from these materials for these applications.

[0035] Furthermore, the tolerances of manufacture and thermal characteristics of the ceramic rotors make them particularly suitable for twin shaft pumps where the problem of maintaining tight clearances across a temperature range are particularly challenging.

[0036] One example of a ceramic material used in the production of these rotors is Zirconia Toughened Alumina (ZTA) type CeramTec DC 25. This material combines the pre-requisite hardness and chemical resistance, with thermal compatibility with other materials of construction within the pump.

[0037] Although this specific ceramic provides an effective rotor, other ceramics including commercially available ceramic products could be used as rotors in these pumps.

[0038] Figure 1 shows two ceramic rotors 10 mounted within the stator 20 of a twin shaft Roots-type pump. The rotors are manufactured such that the clearances x between the rotors 10 and those y between the rotors 10 and stator 20 are low (they are magnified in the Figure). This is possible due to the high tolerances of manufacture and owing to the sympathetic thermal expansion properties of the rotors and the other components of the pump, allowing these clearances not to change substantially across a temperature operating range.

[0039] In this embodiment, the stator 20 is lined with a ceramic lining 22. The ceramic lining provides a protective lining to the stator which protects the stator from the aggressive environment of the pumped gases. The lining is located within the predominantly metal stator 20, which stator provides a protective compartment which would contain the rotor were it to fail.

[0040] 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.

REFERENCE SIGNS

[0041]

10	ceramic rotors
20	stator
22	stator lining
X	clearances between rotors
Y	clearances between rotor and stator

Claims

1. A ceramic rotor configured for a twin shaft pump.

2. A ceramic rotor according to claim 1, said twin shaft pump being configured for operation in semiconductor processing in a high particulate and chemically aggressive environment.

3. A ceramic rotor according to claim 2, wherein said chemically aggressive environment comprises fluorine based gas, such as F_2, NF_3, F, ClF_3.

4. A ceramic rotor according to any preceding claim, wherein said rotor comprises a Zirconia Toughened Alumina type ceramic.

5. A ceramic rotor according to any preceding claim, wherein said rotor comprises a rotor for a Roots-type pump.

6. A ceramic rotor according to any one of claims 1 to 4, wherein said rotor comprises a rotor for a Northey-type pump, screw pumps.

7. A ceramic rotor according to any one of claims 1 to 4, wherein said rotor comprises a rotor for a twin shaft screw pump.

8. A ceramic rotor according to any preceding claim said ceramic rotor being configured for operation above a temperature of 150°C.

9. A ceramic rotor according to any preceding claim, said ceramic rotor being configured for operation between 100°C and 300°C.

10. A twin shaft pump comprising a pair of ceramic rotors according to any one of claims 1 to 9.

11. A twin shaft pump according to claim 10, said twin shaft pump comprising a dry pump.

12. A twin shaft pump according to any one of claims 10 or 11, wherein said pump is configured to operate as one of a backing or booster pump in semiconductor processing.

13. A twin shaft pump according to any one of claims 10 to 12, wherein said twin shaft pump is configured for pumping both chemically aggressive and dusty gases.

14. A twin shaft pump according to claim 13, wherein said chemically aggressive gas comprises a fluorine based gas, such as F_2, NF_3, F, ClF_3.

15. A twin shaft pump according to any one of claims 10 to 14, said twin shaft pump comprising a stator comprising a ceramic lining.

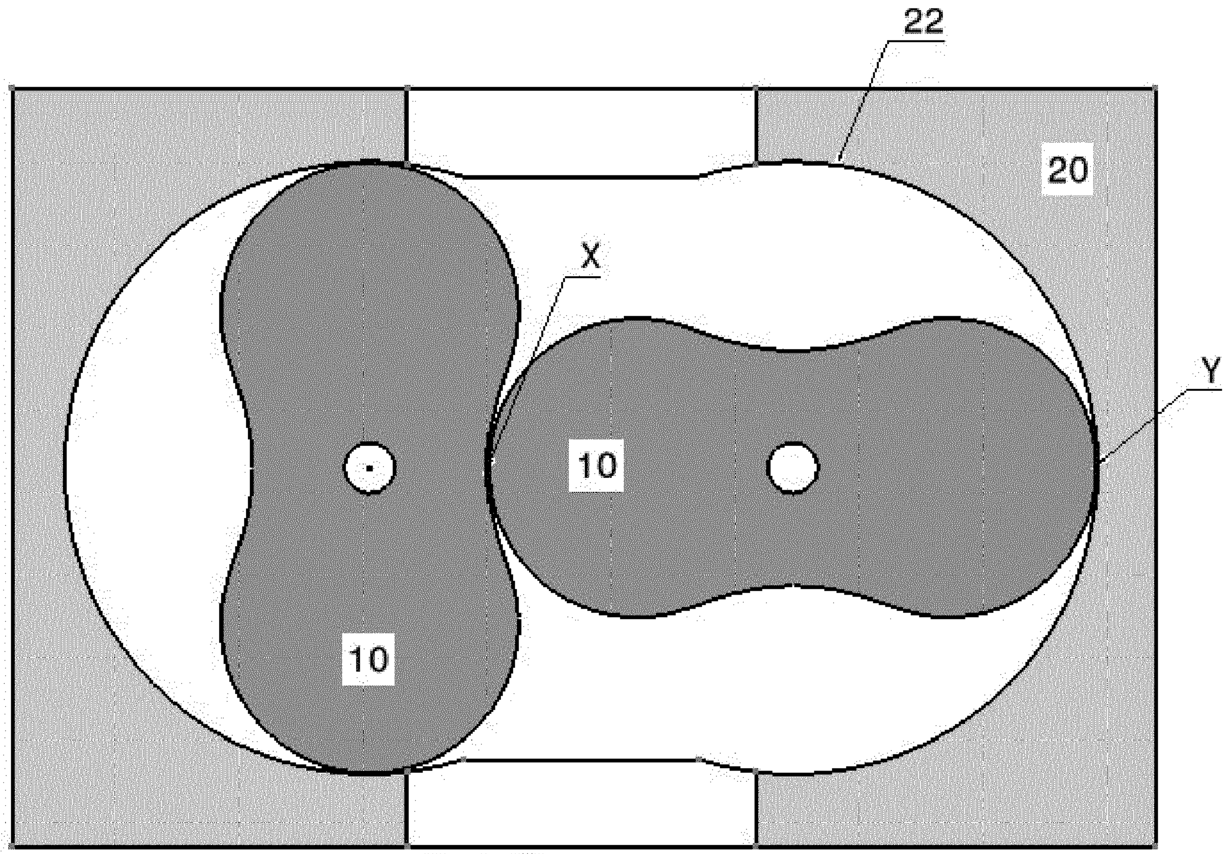

Figure 1

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EUROPEAN SEARCH REPORT

Application Number
EP 19 20 8771

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2005 291135 A (KYOCERA CORP; EBARA CORP) 20 October 2005 (2005-10-20) * figures 1,2 * * paragraph [0020] - paragraph [0031] *	1-6,8-15	INV. F04C18/12 F04C18/16
X	GB 2 477 777 A (UNIV CITY [GB]) 17 August 2011 (2011-08-17) * abstract * * figure 2 * * page 1, line 6 - line 8 * * page 2, line 2 - line 3 *	1,7,10, 11	
X	JP H03 100390 A (HITACHI LTD) 25 April 1991 (1991-04-25) * abstract * * figures 1-3 *	1,7,10, 11	
X	GB 2 501 302 A (UNIV CITY [GB]) 23 October 2013 (2013-10-23) * page 1, line 9 - line 10 * * page 1, line 31 *	1,7,10, 11	TECHNICAL FIELDS SEARCHED (IPC)
X	DE 31 24 247 C1 (BOGE KOMPRESSOREN) 1 June 1983 (1983-06-01) * figure 1 * * abstract * * paragraph [0011] - paragraph [0012] *	1,7,10	F04C
X	JP 2011 231750 A (MIURA KOGYO KK) 17 November 2011 (2011-11-17) * figure 2 * * paragraph [0038] - paragraph [0041] *	1,4,5, 10,15	
X	US 5 393 209 A (US DEPARTMENT OF ENERGY [US]) 28 February 1995 (1995-02-28) * figure 1 * * column 3, line 9 - line 11 * -/--	1,7,8, 10,11	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	4 December 2019	Durante, Andrea

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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Application Number
EP 19 20 8771

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	GB 2 426 036 A (BERNARD WHICHER [GB]; CARAO JORGE [GB]) 15 November 2006 (2006-11-15) * figures * * abstract * -----	1,5,6,10	

TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

1

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page 2 of 2

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04-12-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2005291135 A	20-10-2005	NONE	
GB 2477777 A	17-08-2011	CN 102834618 A	19-12-2012
		EP 2534339 A2	19-12-2012
		GB 2477777 A	17-08-2011
		JP 5964245 B2	03-08-2016
		JP 2013519820 A	30-05-2013
		KR 20120140659 A	31-12-2012
		US 2013052072 A1	28-02-2013
		WO 2011098835 A2	18-08-2011
JP H03100390 A	25-04-1991	NONE	
GB 2501302 A	23-10-2013	CA 2890853 A1	24-10-2013
		CN 104379936 A	25-02-2015
		EP 2852763 A1	01-04-2015
		GB 2501302 A	23-10-2013
		JP 6211591 B2	11-10-2017
		JP 2015518105 A	25-06-2015
		KR 20150007317 A	20-01-2015
		US 2015086406 A1	26-03-2015
		WO 2013156754 A1	24-10-2013
DE 3124247 C1	01-06-1983	NONE	
JP 2011231750 A	17-11-2011	NONE	
US 5393209 A	28-02-1995	NONE	
GB 2426036 A	15-11-2006	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82