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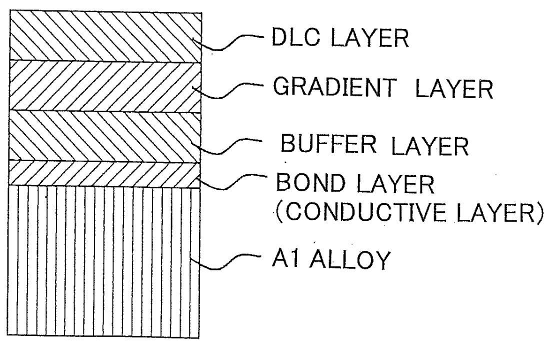
(54) SCROLL COMPRESSOR

(57) [Problem] To provide a scroll compressor which can contribute to reduction in the entire size and the entire weight and has excellent durability and reliability, and which can use a new refrigerant to make ultrahigh speed operation possible.

[Means for Resolution] In the scroll compressor, the substrate of an Oldham-coupling ring 107 is made of an aluminum alloy, and a hard DLC layer is formed on the surface of the substrate with interposition of underlayers provided for obtaining excellent adhesion and compensating for hardness so that the weight of the Oldham-coupling ring is reduced by approximately 1/3, compared with the conventional case where the Oldham-coupling ring is made of an iron-based material. Adhesive wear between sliding members are prevented so that improvement in abrasion resistance and reduction in friction coefficient are achieved. As a result, the inertial mass of a rotation system is reduced. Furthermore, an orbiting scroll 101 also has the same material structure so that the eccentric mass of the rotation system is reduced. Thus, the torque load of a motor 100 can be reduced as sufficiently as possible to thereby contribute to reduction in the entire size and the entire weight to obtain excellent durability and reliability. In addition, the scroll compressor can use a new refrigerant to make ultrahigh speed operation possible so that compressing performance equivalent to the case where chlorofluorocarbon is used can be obtained.

FIG.4



EP 2 541 065 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a scroll compressor with a compact and lightweight structure, which is suitably used as a compressor for a refrigerating cycle in an air-conditioning and hot-water-supply system for new-generation housings with high eco (ecological) effects, which can use a new refrigerant with a low global warming potential (GWP) to make wide range operation in a motor system drive signal frequency possible, and which particularly has excellent durability and reliability at an ultrahigh speed operation.

BACKGROUND ART

[0002] An iron-based material which is hard and has high abrasion resistance has been heretofore generally used for an Oldham-coupling ring and an orbiting scroll which are slide members having high sliding performance at the time of operation in a scroll compressor used in a refrigerating and air-conditioning circuit (also referred to as refrigerant cycle) of an air-conditioner or a refrigerator.

[0003] Chlorofluorocarbon which has been heretofore broadly used as a refrigerant for refrigerating cycle has a high global warming potential (GWP), and there is a risk that chlorofluorocarbon will destroy an ozone layer. Therefore, there is a worldwide tendency toward regulation on use of chlorofluorocarbon. For this reason, it has recently come to a stage for using a new refrigerant with a low global warming potential (GWP). However, the new refrigerant is not superior in heat exchanger effectiveness to chlorofluorocarbon. In order to obtain equivalent compression performance to that of a scroll compressor having a conventional structure, it is necessary either to increase the entire volume of a compressor or to drive a crankshaft (rotation main shaft) to rotate at a high speed as ultrahigh speed operation.

[0004] However, the measure to increase the entire volume of a compressor will lead to increase in the entire size of the compressor structurally. The measure to rotate a crankshaft (rotary main shaft) at a high speed will lead to increase in the load of a motor so that a high power consumption type inverter will be also required as a drive-side inverter. This will lead to increase in scale and cost of an electric circuit system. In any case, these measures are against the current demands made recently for reduction in size, weight and cost. Therefore, it cannot be said that these measures are good. As to the new refrigerant, it is necessary to improve the abrasion resistance and to reduce the friction coefficient in the sliding members in the internal structure of the compressor, compared with the case where chlorofluorocarbon is used.

[0005] Therefore, there has been proposed a technique for not making structural improvement of the compressor or improvement of the electric circuit system but contriving materials of the internal structure of the compressor to ensure some degree of operation performance even with a new refrigerant and achieve improvement in the abrasion resistance and reduction in the friction coefficient in the sliding members.

[0006] Even when, for example, a chlorine-free alternative refrigerant or a natural refrigerant is used, there have been a scroll type motor-driven compressor (see Patent Literature 1) using a sliding member which can be further improved in abrasion resistance so as to be free from long-term maintenance, a compressor (see Patent Literature 2) including a constituent member improved in abrasion resistance by reducing its friction coefficient, a rotary type fluid machine (see Patent Literature 3) in which a fixed scroll or an orbiting scroll (movable scroll) as a sliding portion is formed from an aluminum substrate, and an Ni-P plating layer and a DLC (Diamond-Like Carbon) thin film are formed successively on a surface of the aluminum substrate, etc.

CITATION LIST

PATENT LITERATURE

[0007]

Patent Literature 1: JP-A-2008-261261
Patent Literature 2: JP-A-2001-115959
Patent Literature 3: JP-A-2006-200455

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0008] In the aforementioned technique according to Patent Literature 1, an oxide film layer, an oxide layer, an intermediate layer and a hard carbon film layer are formed successively on a surface of a sliding member made of sintered iron so that the hard carbon film layer of DLC or the like excellent in abrasion resistance and low friction characteristic is stuck on the outer surface. Although the sliding member is excellent in abrasion resistance and low friction characteristic during operation, the substrate per se of the sliding member is made of sintered iron so that the eccentric mass is large as in the conventional case. Therefore, when ultrahigh speed operation is intended in the case where a new refrigerant is used, the load of a motor becomes very large. As a result, there is a problem that it is difficult to achieve ultrahigh speed operation and weight reduction on the basic structure.

[0009] On the other hand, in the technique according to Patent Literature 2, as to a sliding member which is a constituent member of the compressor, an orbiting scroll is made from an aluminum substrate, and a resin material formed to contain a carbon fiber and a solid lubricant and DLC are formed successively on a surface of the aluminum substrate so that the DLC is stuck. Because the eccentric mass of the orbiting scroll is smaller than that in the cited Literature 1, the load of a motor can be suppressed to some degree to thereby attain ultrahigh speed operation and weight reduction. However, an Oldham-coupling ring whose mechanical strength and abrasion resistance are required is made of an iron-based material here. Accordingly, it is difficult to achieve ultrahigh speed operation and weight reduction satisfactorily on the basic structure.

[0010] Further, also in the technique according to Patent Literature 3, the orbiting scroll (movable scroll) is made from an aluminum substrate, and an Ni-P plating layer and a DLC thin film are formed successively on a surface of the aluminum substrate, similarly to the technique according to Patent Literature 2. Accordingly, it is difficult to achieve ultrahigh speed operation and weight reduction satisfactorily on the basic structure.

[0011] In addition, in the technique according to Patent Literature 2 or Patent Literature 3, the DLC is stuck on the surface of the resin material or the Ni-P plating layer formed on the surface of the aluminum substrate. Generally, it is known well that it is difficult to stick the DLC on the surface of a metal material, and that it is necessary to contrive an underlayer for ensuring the adhesion. If the underlayer is made of only the resin material or the Ni-P plating layer, there is a risk that the adhesion cannot be kept stably for a long term under such usage conditions that the underlayer is exposed to a high pressure gas due to a new refrigerant and considerable heating caused by sliding is assumed. Particularly, since the aluminum substrate is sufficiently softer than iron, and the DLC in the surface is hard, there is also a risk that the DLC will deform the underlayer or the aluminum substrate or the DLC will be separated due to the degree of deformation of the underlayer or the aluminum substrate on the assumption that the hard DLC suffers sliding under high pressure conditions.

[0012] In addition, the reason why the Oldham-coupling ring in the technique according to Patent Literature 2 is made of an iron-based material is conceived as follows. When the eccentric mass is intended to be reduced at the time of ultrahigh speed operation of the slide members of the compressor, the orbiting scroll can attain mass balance structurally to cancel the eccentric mass because the orbiting scroll is rotated eccentrically, but the Oldham-coupling ring cannot attain mass balance structurally to cancel the eccentric mass because the Oldham-coupling ring is reciprocated to arrest rotary motion of the orbiting scroll but promote orbital motion of the orbiting scroll.

[0013] However, in the view point of reduction in the inertial mass of a rotation system in order to reduce the load of the motor, reduction in the weight of the Oldham-coupling ring is favorable and can contribute to reduction in the entire size and weight of the compressor more preferably.

[0014] The invention is accomplished to solve such a problem. A technical object of the invention is to provide a scroll compressor which can contribute to reduction in entire size and weight of the compressor, which is excellent in durability and reliability, and which can use a new refrigerant to make ultrahigh speed operation possible.

SOLUTION TO PROBLEM

[0015] In order to solve the foregoing technical problem, according to the invention, there is provided a scroll compressor having a structure in which a spiral body of an orbiting scroll and a spiral body of a fixed scroll are engaged with each other in a sealed case, the orbiting scroll is attached, with interposition of a frame, to one end side of a crankshaft serving as a rotary main shaft for attaching a rotating portion of a motor in a substantially central portion, and an Oldham-coupling ring disposed between the orbiting scroll and the frame arrests rotary motion of the orbiting scroll but promotes orbital motion of the orbiting scroll when the crankshaft rotates, characterized in that: the Oldham-coupling ring is made of an aluminum alloy as a substrate, and a bond layer for improving adhesion, a buffer layer for compensating for hardness of the aluminum alloy substrate and a hard DLC layer are formed successively on a surface of the aluminum alloy substrate. Preferably, in the scroll compressor, the aluminum alloy is coated with an oxide film.

[0016] An embodiment of the aforementioned scroll compressor is characterized in that: a gradient layer made of a mixture of carbon and a metal or metal carbide is interposed between the buffer layer and the DLC layer so that content of the metal decreases as the position goes from the aluminum alloy substrate toward the outside and content of the carbon increases as the position goes from the aluminum alloy substrate toward the outside.

[0017] Further, another embodiment of the aforementioned scroll compressor is characterized in that: a gradient layer made of a mixture of metals or metal carbide is interposed between the buffer layer and the DLC layer so that content of a first metal decreases as the position goes from the aluminum alloy substrate toward the outside and content of the carbon and a second metal different from the first metal increases as the position goes from the aluminum alloy substrate toward the outside.

[0018] In addition, a further embodiment of the aforementioned scroll compressor is characterized in that: the DLC layer contains 0.5 at% to 4.5 at% of aluminum. Preferably, the aluminum is in one state selected from metal, boride, carbide, nitride, oxide, and hydroxide.

[0019] A further embodiment of the aforementioned scroll compressor is characterized in that: the DLC layer is made of a mixture of SP^2-hybridized carbon and SP^3-hybridized carbon.

[0020] As a further embodiment of the aforementioned scroll compressor, preferably, the orbiting scroll has the same material structure as the Oldham-coupling ring.

ADVANTAGEOUS EFFECTS OF INVENTION

[0021] According to the scroll compressor in the invention, the substrate of the Oldham-coupling ring is made of an aluminum alloy, and a hard DLC layer is formed on the surface of the aluminum alloy substrate with interposition of underlayers provided for obtaining excellent adhesion and compensating for hardness. Accordingly, the Oldham-coupling ring can be reduced by approximately 1/3, compared with the conventional case where the Oldham-coupling ring is made of an iron-based material. In addition, adhesive wear between the sliding members is prevented so that improvement in abrasion resistance and reduction in friction coefficient are achieved. As a result, the inertial mass of a rotation system can be reduced. Moreover, the orbiting scroll also has the same material structure so that the eccentric mass of the rotation system can be reduced satisfactorily. Further, the hard DLC layer including the underlayers is formed on the surface of the aluminum alloy substrate by a film forming process at a low temperature which does not cause lowering of strength of the aluminum alloy substrate. As a result, the torque load of the motor can be reduced as sufficiently as possible to thereby contribute to reduction in the entire size and weight to obtain excellent durability and reliability. The scroll compressor can use a new refrigerant to make ultrahigh speed operation possible so that compressing performance equivalent to that in the case where chlorofluorocarbon is used can be obtained at a low cost.

BRIEF DESCRIPTION OF DRAWINGS

[0022]

[Fig. 1] A side view showing the schematic configuration of a scroll compressor according to Example 1 of the invention as a section along a direction of extension of a rotary main shaft.

[Fig. 2] A perspective view showing the external appearance of an Oldham-coupling ring provided in the scroll compressor shown in Fig. 1.

[Fig. 3] A local sectional view showing an example of a multi-layer structure with respect to materials of the Oldham-coupling ring and an orbiting scroll provided in the scroll compressor shown in Fig. 1.

[Fig. 4] A local sectional view showing another example of the multi-layer structure with respect to materials of the Oldham-coupling ring and the orbiting scroll provided in the scroll compressor shown in Fig. 1.

DESCRIPTION OF EMBODIMENTS

[0023] Fig. 1 is a side view showing the schematic configuration of a scroll compressor according to Example 1 of the invention as a section along a direction of extension of a rotary main shaft.

[0024] The scroll compressor has a structure as a well-known conventional basic structure in which: a fixed scroll 102 having a spiral body is attached on an end side in a sealed case (chamber) 115 having a suction port for mounting a suction pipe 113 for sucking a new refrigerant gas and a discharge port for mounting a discharge pipe 114 for discharging the refrigerant gas; an assembly formed in such a manner that an orbiting scroll 101 having a counterpart spiral body is attached, with interposition of a frame 105, on one axial end side of a crankshaft 106 serving as a rotary main shaft for attaching a rotor 100a of a motor 100 (having the rotor (rotating portion) 110a and a stator (fixed portion) 110b) in a substantially central portion, and a shaft support member based on a bearing support plate 111 and a sub bearing 112 is attached on the other end side of the crankshaft 106 is put in the remaining space portion in the sealed case 115 so that the spiral body of the orbiting scroll 101 and the spiral body of the fixed scroll 102 are engaged with each other; and the respective parts are attached, sealed and housed.

[0025] As for a detailed structure, in the sealed state, an eccentric portion 106a of the crankshaft 106 supported by a main bearing 105a of the frame 105 is inserted in an orbiting shaft bearing attached to the back of the orbiting scroll 101 1 so that an Oldham-coupling ring 107 disposed between the orbiting scroll 101 and the frame 105 arrests rotary motion of the orbiting scroll 101 but promotes orbital motion of the orbiting scroll 101 when the crankshaft 106 rotates.

[0026] The pressure (back-pressure value) in a back-pressure chamber 109 formed by the fixed scroll 102, the orbiting scroll 101 and the frame 105 is controlled by a differential pressure control mechanism 109a. Thus, the orbiting scroll 101 is pressed against the fixed scroll 102. The differential pressure control mechanism 109a has a pressure inlet side which communicates with the back-pressure chamber 109, and a pressure outlet side which communicates with a fixed outer circumferential groove provided in an outer circumference of the spiral body of the fixed scroll 102. The fixed outer circumferential groove communicates with the refrigerant gas suction port. Thus, the inside pressure of the fixed outer circumferential groove is always set as a suction pressure.

[0027] The suction pipe 113 is provided for sucking the refrigerant gas. The suction pipe 113 communicates with the fixed scroll 102. The discharge pipe 114 is provided for discharging the compressed refrigerant gas to the outside. The sub bearing 112 attached to the shaft bearing support plate 111 in a lower portion of the motor 110 works with the main bearing 105a of the frame 105 to support the crankshaft 106. Incidentally, the room in the sealed case 115 on the other axial end side of the crankshaft 106 is used as an oil reservoir chamber 116 for reserving oil.

[0028] Compressing operation of the scroll compressor having such a structure will be described. When the motor 110 is driven to rotate the rotor 100a and the crankshaft 106, the orbiting scroll 101 starts orbital motion accordingly. By this operation, the spiral body of the orbiting scroll 101 and the spiral body of the fixed scroll 102 are engaged with each other to form a first compression chamber and a second compression chamber.

[0029] On this occasion, the refrigerant gas flowing in from the suction pipe 113 is compressed in the first compression chamber and the second compression chamber. In the first compression chamber and the second compression chamber, a compressing operation is performed while the volume is reduced toward the center in accordance with rotation of the crankshaft 106. Thus, the highly pressurized refrigerant gas is discharged from a discharge port 108 formed in the fixed scroll 102 to discharge chambers 103 and 104 in the sealed case 115 and finally discharged to the outside through the discharge pipe 114.

[0030] The pressure of the back-pressure chamber 109 increases due to a gas contained in oil for lubricating the main bearing 105a of the frame 105, etc., and is controlled by the differential pressure control mechanism 109a to form a constant pressure difference from the suction pressure. This pressure is an intermediate pressure to be about intermediate between the suction pressure and the discharge pressure so that the orbiting scroll 101 is pressed against the fixed scroll 102. By the pressing on this occasion, an end plate of the orbiting scroll 101 is in close contact with the fixed scroll 102 so that the intermediate pressure in the back-pressure chamber 109 is sealed by the end plate of the orbiting scroll 101.

[0031] A new refrigerant with a low global warming potential (GWP) such as CO_2 or HFC152a used in the scroll compressor according to Example 1 is lower in heat exchanger effectiveness than the conventional case of chlorofluorocarbon. Accordingly, in order to obtain a compressing function equivalent to that in the case where chlorofluorocarbon is used, it is necessary either to increase capacity or to operate the scroll compressor at an ultrahigh speed without change of the capacity. It is necessary to increase the entire size of the compressor in order to increase the capacity as described above. However, this method cannot be adopted practically because this method is against the current demands for reduction in size and weight.

[0032] Therefore, when conditions for operating the scroll compressor at an ultrahigh speed without change of the capacity are considered, it is desirable that materials of the orbiting scroll 101 as a sliding member are contrived to achieve reduction in weight as in Patent Literature 2 or Patent Literature 3 to reduce the eccentric mass, and that the inertial mass of a rotary system is reduced to reduce the load of the motor 100 as sufficiently as possible.

[0033] However, in the structure in which an aluminum-based material is used as the substrate of the orbiting scroll 101 and a resin material or an Ni-P plating layer is used as an underlayer for forming a hard DLC layer on a surface of the substrate as in Patent Literature 2 or Patent Literature 3, there is a fear that the adhesion cannot be kept stably for a long term or there is a risk that the DLC will be separated. That is, when a measure is taken by the method of Patent Literature 2 or Patent Literature 3, it is difficult to satisfactorily achieve ultrahigh speed operation and weight reduction on the basic structure, and the durability of the sliding member having the DLC layer formed therein is problematic.

[0034] Therefore, in the scroll compressor according to Example 1, attention is paid to improvement in the material of the Oldham-coupling ring 107 disposed between the orbiting scroll 101 and the frame 105.

[0035] Fig. 2 is a perspective view showing the external appearance of the Oldham-coupling ring 107 provided in the aforementioned scroll compressor.

[0036] The Oldham-coupling ring 107 has a substantially annular shape in external appearance similarly to the conventional case. Convex orbiting-side keys 107a for arresting rotary motion of the orbiting scroll 101 are provided on an outer circumferential edge of a surface on the orbiting scroll 101 side so as to be located in two places in a radial direction passing through the center. In addition, convex frame-side keys 107b are also provided on an outer circumference of a surface on the frame 105 side so as to be located in two places in a radial direction passing through the center and perpendicular to the radial direction of the orbiting-side keys 107a.

[0037] Here, the Oldham-coupling ring 107 is formed in such a manner that an aluminum alloy is used as the substrate, and that a bond layer (conductive layer) for increasing adhesion, a buffer layer for compensating for hardness of the aluminum alloy substrate, and a hard DLC layer are formed successively on a surface of the aluminum alloy substrate. The orbiting scroll 101 also has the same material structure. In any case, the aluminum alloy mentioned here may be covered with an oxide film.

[0038] Among them, the case where the bond layer (conductive layer) contains one of metals such as chrome (Cr) and titanium (Ti) may be exemplified.

[0039] The case where the buffer layer contains one of chromium nitride (CrN), chromium carbide (CrC), titanium nitride (TiN) and titanium carbide (TiC) may be exemplified.

[0040] A gradient layer made of a mixture of carbon and a metal or metal carbide may be interposed between the aforementioned buffer layer and the aforementioned DLC layer so that the metal is one of aluminum (Al), chrome (Cr) and titanium (Ti), the content of the metal decreases as the position goes from the aluminum alloy substrate toward the outside and the content of carbon increases as the position goes from the aluminum alloy substrate toward the outside. Alternatively, a gradient layer made of a mixture of metals or metal carbide may be interposed between the buffer layer and the DLC layer so that the metals are a first metal and a second metal each selected from aluminum (Al), chrome (Cr) and titanium (Ti), the content of the first metal decreases as the position goes from the aluminum alloy substrate toward the outside, and the content of carbon and the second metal different from the first metal increases as the position goes from the aluminum alloy substrate toward the outside.

[0041] In addition, the DLC layer may contain 0.5 at% to 4.5 at% of aluminum. Here, it is preferable that aluminum is in one state selected from metal, boride, carbide, nitride, oxide, and hydroxide. Further, the DLC layer may be made of a mixture of SP^2-hybridized carbon and SP^3-hybridized carbon.

[0042] When the Oldham-coupling ring 107 and the orbiting scroll 101 which serve as such sliding members are produced by forming the aforementioned material structure in multiple layers on the surface of the aluminum alloy substrate, a first step of forming a bond layer (conductive layer) on the surface of the aluminum alloy substrate by a sputtering method or an ion plating method, and a second step of forming a buffer layer (further forming a gradient layer on the buffer layer if necessary) on the bond layer (conductive layer) for the purposes of improving adhesion and compensating for hardness in the condition that a bias voltage is applied to the aluminum alloy substrate, and forming a DLC layer (containing aluminum or containing a mixture of SP^2-hybridized carbon and SP^3-hybridized carbon if necessary) on the buffer layer (or on the gradient layer) may be carried out.

[0043] In any case, when each of the Oldham-coupling ring 107 and the orbiting scroll 101 which are sliding members is made of an aluminum alloy substrate simply in order to reduce the eccentric mass of the rotation system, the aluminum alloy is generally soft and inferior in sliding performance so that abrasion resistance tolerable to ultrahigh speed operation cannot be obtained if a high sliding speed and a large amount of generated heat are considered. When the Oldham-coupling ring 107 and the orbiting scroll 107 are simply made of the same metal materials (aluminum alloys), the orbiting scroll 101 and the orbiting-side keys 107a of the Oldham-coupling ring 107 are unfavorably apt to cause adhesive wear.

[0044] Therefore, when each of the Oldham-coupling ring 107 and the orbiting scroll 101 is made of not only an aluminum alloy substrate but also a hard DLC layer formed on the surface in the aforementioned material structure, adhesive wear can be prevented so that heating caused by sliding can be reduced. Incidentally, since the aluminum alloy is small in elastic modulus and large in linear expansion coefficient, a hard DLC layer is apt to be separated if the aluminum alloy is simply coated with the hard DLC layer. Therefore, interposition of the bond layer (conductive layer) and the gradient layer is important for ensuring adhesion and hardness and preventing separation. In addition, it can be said that it is difficult to use a CVD process etc. at high processing temperature for formation of the underlayers because the CVD process etc. will cause lowering of strength.

[0045] Fig. 3 is a local sectional view showing an example of a multi-layer structure with respect to materials of the Oldham-coupling ring 107 and the orbiting scroll 101.

[0046] With reference to Fig. 3, the multi-layer structure mentioned here is formed in such a manner that a bond layer (conductive layer), a buffer layer, a gradient layer, and a DLC layer are formed successively on the surface of each of the Oldham-coupling ring 107 and the orbiting scroll 101 1 containing an aluminum alloy substrate coated with an oxide film (i.e. on the oxide film of the aluminum alloy substrate).

[0047] Fig. 4 is a local sectional view showing another example of the multi-layer structure with respect to materials of the Oldham' s Oldham-coupling ring 107 and the orbiting scroll 101.

[0048] With reference to Fig. 4, the multi-layer structure mentioned here is formed in such a manner that a bond layer (conductive layer), a buffer layer, a gradient layer, and a DLC layer are formed successively on the surface of each of the Oldham' s Oldham-coupling ring 107 and the orbiting scroll 101 containing an aluminum alloy substrate not coated with an oxide film.

[0049] In the scroll compressor provided with the Oldham-coupling ring 107 and the orbiting scroll 101 having these multi-layer structure and material structure, the substrate of the Oldham-coupling ring 107 is basically made of an aluminum alloy and a hard DLC layer is formed on the surface of the substrate with interposition of underlayers for obtaining excellent adhesion and compensating for hardness. Accordingly, the weight of the Oldham-coupling ring 107 can be reduced by approximately 1/3, compared with the conventional case where the Oldham-coupling ring is made of an iron-based material. In addition, adhesive wear between the sliding members can be prevented, so that the abrasion resistance can be improved and the friction coefficient can be reduced. As a result, the inertial mass of a rotation system can be reduced. In addition, the orbiting scroll 101 also has the same multi-layer structure and material structure, so that the eccentric mass of the rotation system can be reduced. Further, the hard DLC layer including the underlayers can be formed on the surface of the aluminum alloy substrate by a film forming process at a low temperature which does not cause lowering of strength of the aluminum alloy substrate. As a result, the torque load of the motor 100 can be reduced as sufficiently as possible to thereby contribute to reduction in the entire size and weight of the compressor to obtain excellent durability and reliability. In addition, the compressor can use a new refrigerant to make ultrahigh speed operation (at a frequency of about 200Hz in a drive signal to the motor 100) possible so that compressing performance equivalent to that in the case where chlorofluorocarbon is used can be obtained at a low cost.

DESCRIPTION OF REFERENCE SIGNS LIST

[0050]

101	orbiting scroll
102	fixed scroll
103, 104	discharge chamber
105	frame
105a	main bearing
106	crankshaft
106a	eccentric portion
107	Oldham-coupling ring
107a	orbiting-side key
107b	frame-side key
108	discharge port
109	back-pressure chamber
109a	differential pressure control mechanism
110	motor
110a	rotor
110b	stator
111	shaft bearing support plate
112	sub bearing
113	suction pipe
114	discharge pipe
115	sealed case (chamber)
116	oil reservoir chamber

Claims

1. A scroll compressor having a structure in which a spiral body of an orbiting scroll and a spiral body of a fixed scroll are engaged with each other in a sealed case, the orbiting scroll is attached, with interposition of a frame, to one end side of a crankshaft serving as a rotary main shaft for attaching a rotating portion of a motor in a substantially central portion, and an Oldham-coupling ring disposed between the orbiting scroll and the frame arrests rotary motion of the orbiting scroll but promotes orbital motion of the orbiting scroll when the crankshaft rotates, **characterized in that**:

   the Oldham-coupling ring is made of an aluminum alloy as a substrate, and a bond layer for improving adhesion, a buffer layer for compensating for hardness of the aluminum alloy substrate and a hard diamond-like carbon layer are formed successively on a surface of the aluminum alloy substrate.

2. A scroll compressor according to Claim 1, **characterized in that**: the aluminum alloy is coated with an oxide film.

3. A scroll compressor according to Claim 1, **characterized in that**: a gradient layer made of a mixture of carbon and a metal or metal carbide is interposed between the buffer layer and the diamond-like carbon layer so that content of the metal decreases as the position goes from the aluminum alloy substrate toward the outside and content of the carbon increases as the position goes from the aluminum alloy substrate toward the outside.

4. A scroll compressor according to Claim 1, **characterized in that**: a gradient layer made of a mixture of metals or metal carbide is interposed between the buffer layer and the diamond-like carbon layer so that content of a first metal decreases as the position goes from the aluminum alloy substrate toward the outside and content of the carbon and a second metal different from the first metal increases as the position goes from the aluminum alloy substrate toward the outside.

5. A scroll compressor according to Claim 1, **characterized in that**: the diamond-like carbon layer contains 0.5 at% to 4.5 at% of aluminum.

6. A scroll compressor according to Claim 5, **characterized in that**: the aluminum is in one state selected from metal, boride, carbide, nitride, oxide, and hydroxide.

7. A scroll compressor according to Claim 1, **characterized in that**: the diamond-like carbon layer is made of a mixture of SP^2-hybridized carbon and SP^3-hybridized carbon.

8. A scroll compressor according to Claim 1, **characterized in that**: the orbiting scroll is made of the aluminum alloy as a substrate, and the bond layer, the buffer layer and the diamond-like carbon layer are formed successively on the surface of the aluminum alloy substrate.

9. A scroll compressor according to Claim 8, **characterized in that**: the aluminum alloy is coated with an oxide film.

10. A scroll compressor according to Claim 8, **characterized in that**: a gradient layer made of a mixture of carbon and a metal or metal carbide is interposed between the buffer layer and the diamond-like carbon layer so that content of the metal decreases as the position goes from the aluminum alloy substrate toward the outside and content of the carbon increases as the position goes from the aluminum alloy substrate toward the outside.

11. A scroll compressor according to Claim 8, **characterized in that**: a gradient layer made of a mixture of metals or metal carbide is interposed between the buffer layer and the diamond-like carbon layer so that content of a first metal decreases as the position goes from the aluminum alloy substrate toward the outside and content of the carbon and a second metal different from the first metal increases as the position goes from the aluminum alloy substrate toward

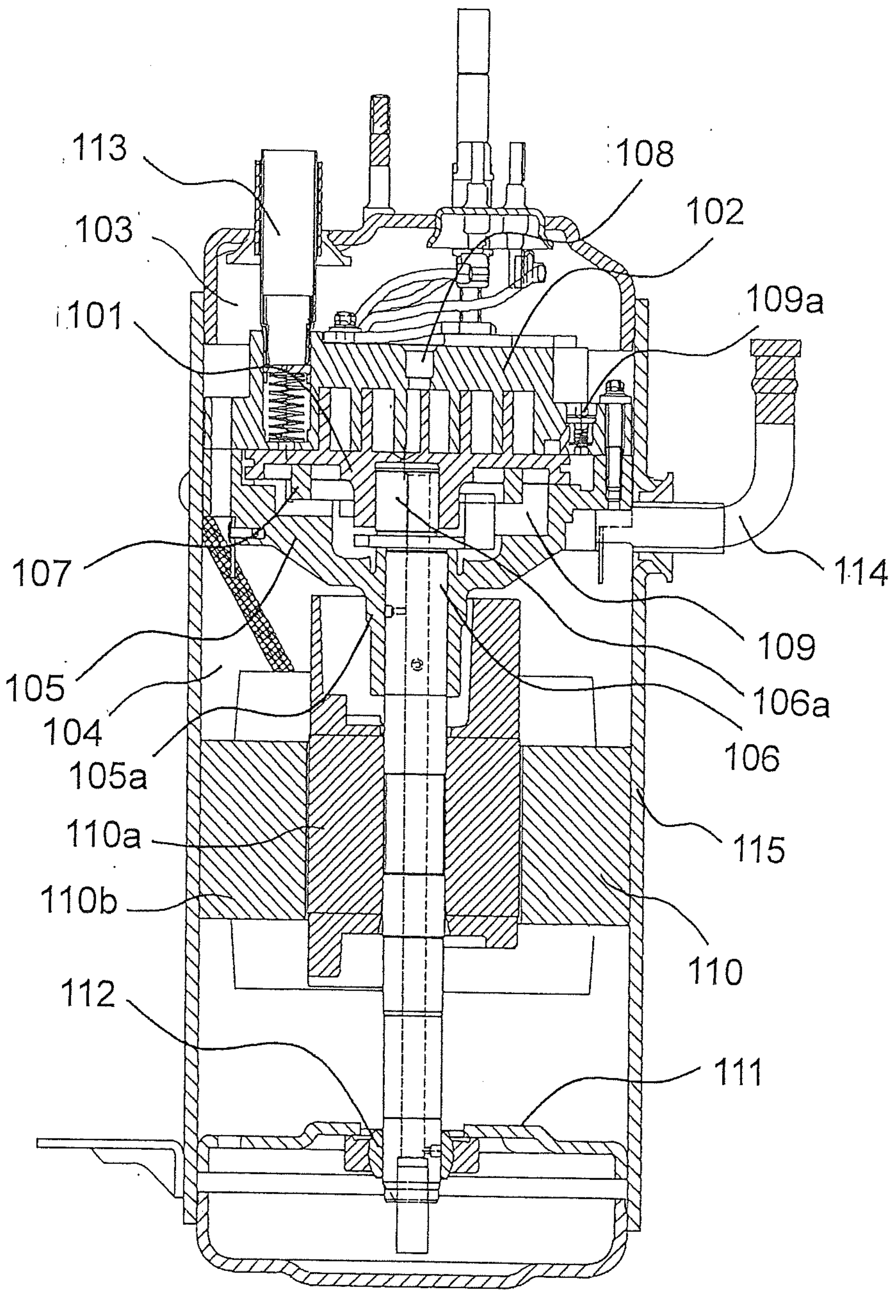
the outside.

12. A scroll compressor according to Claim 8, **characterized in that**: the diamond-like carbon layer contains 0.5 at% to 4.5 at% of aluminum.

13. A scroll compressor according to Claim 12, **characterized in that**: the aluminum is in one state selected from metal, boride, carbide, nitride, oxide, and hydroxide.

14. A scroll compressor according to Claim 8, **characterized in that**: the diamond-like carbon layer is made of a mixture of SP^2-hybridized carbon and SP^3-hybridized carbon.

FIG. 1


113
103
101
108
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109a
107
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104
106a
105a
106
110a
115
110b
110
112
111

FIG. 2

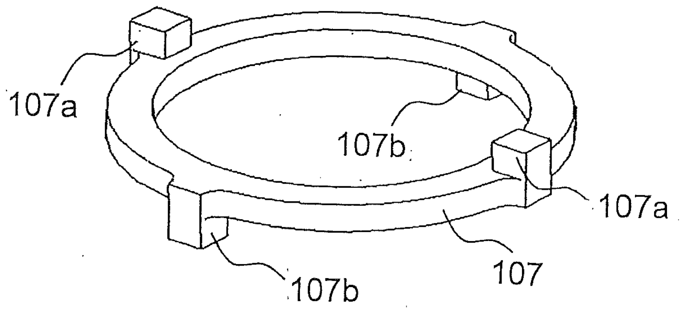


FIG.3

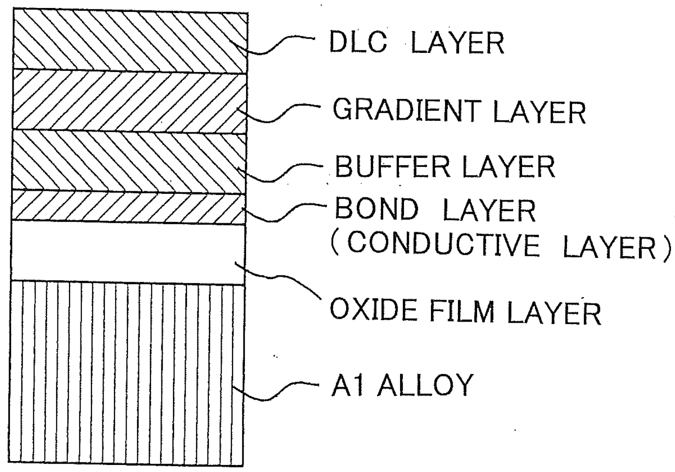
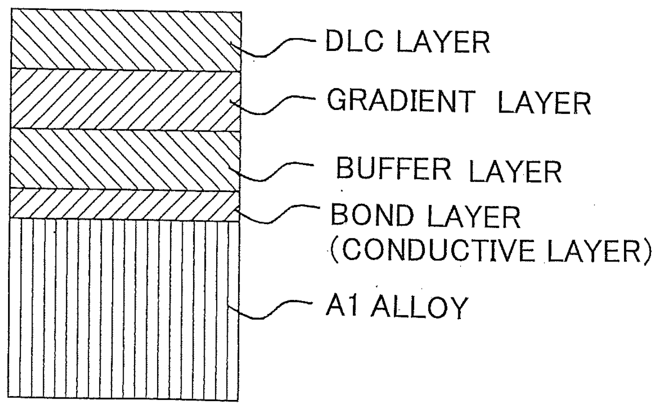


FIG.4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/053139

A. CLASSIFICATION OF SUBJECT MATTER
F04C18/02(2006.01)i, *F04C29/00*(2006.01)i

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)
F04C18/02, F04C29/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 7-77180 A (Hitachi, Ltd.), 20 March 1995 (20.03.1995), claim 1; paragraphs [0006] to [0008]; fig. 6 to 7 (Family: none)	1-14
Y	JP 2008-69372 A (Hitachi, Ltd.), 27 March 2008 (27.03.2008), claims 1 to 5; paragraphs [0029] to [0040] & US 2008/0063894 A1 & EP 1900844 A2	1-3,5-10, 12-14
Y	JP 2001-225412 A (Kabushiki Kaisha Token Samotekku), 21 August 2001 (21.08.2001), claims 1 to 3; paragraphs [0003] to [0009]; fig. 2 (Family: none)	1-2,4,7-9, 11,14

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
11 May, 2010 (11.05.10)	25 May, 2010 (25.05.10)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/053139

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 53-99080 A (ULVAC Japan Ltd.), 30 August 1978 (30.08.1978), claims; page 2, lower left column, lines 1 to 10; fig. 1 (Family: none)	2
A	JP 2008-261261 A (Hitachi Appliances, Inc.), 30 October 2008 (30.10.2008), claim 1; paragraphs [0014], [0027]; fig. 5 (Family: none)	2

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008261261 A **[0007]**
- JP 2001115959 A **[0007]**
- JP 2006200455 A **[0007]**