



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.01.2003 Bulletin 2003/02

(51) Int Cl.7: **F04D 19/04**, F04D 29/58,
F04D 29/02

(21) Application number: **02254522.2**

(22) Date of filing: **27.06.2002**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **03.07.2001 JP 2001202297**

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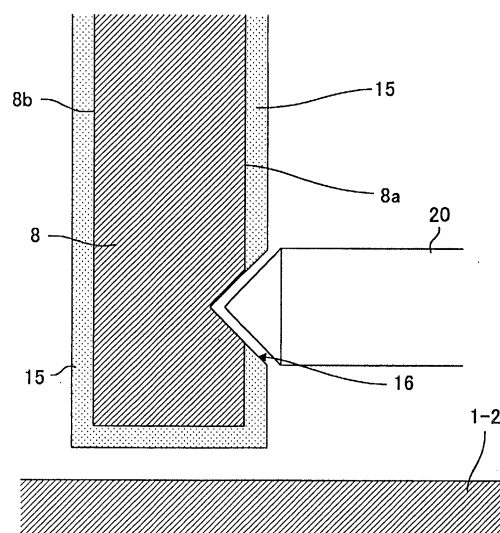
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(54) **Vacuum pump**

(57) To provide a vacuum pump in which destruction of a rotational body due to corrosion can be prevented, and in which deposition of product is reduced, preventing damage due to contact between the rotational body and a fixed side. The pump case having the gas inlet port opened on its upper surface, the rotor shaft supported within the pump case such that it is capable of rotating, the plurality of the rotor blades formed in the outer circumferential surface of the rotor that is fixed to the rotor shaft, the plurality of the stator blades fixed within the pump case, positioned alternately with the plurality of the rotor blades, and the driving motor for rotating the rotor shaft are provided. The corrosion preventing film layer is formed on the inner circumferential surface and the outer circumferential surface of the rotor, and the balancing holes are formed by removing a portion of the inner circumferential surface or the outer circumferential surface of the rotor, and the thermosetting resin film layer is formed on the surface of the balancing holes as an anti-corrosion process.

FIG. 2



Description

[0001] The present invention relates to a vacuum pump used for a semiconductor manufacturing apparatus, an electron microscope, a surface analysis apparatus, a mass spectrometer, a particle accelerator, an experimental fusion apparatus, or the like. In particular, the invention relates to a vacuum pump in which anti-corrosive processing is necessary, like one used in a semiconductor manufacturing apparatus.

[0002] Conventionally, in a process step performing a processing within a high vacuum chamber, such as a process step of dry etching or CVD in a semiconductor manufacturing process, a vacuum pump such as a turbo molecular pump is used as means for exhausting gas within a processing chamber, for forming a given high vacuum degree.

[0003] A rotational body of this type of vacuum pump is normally formed of an aluminum alloy. However, in case of a vacuum pump that is used under such a severe environment as a semiconductor manufacturing process, in which the vacuum pump is exposed to corrosive chlorine and fluorine sulfide gasses, an anti-corrosive processing is performed in which the surface of a rotational body made from an aluminum alloy is coated with an anti-corrosive prevention film such as a nickel phosphorous alloy plating.

[0004] On the other hand, in vacuum pumps having a rotational body as stated above, it becomes necessary to perform balancing of the rotational body during high speed rotation at the pump assembly stage of manufacturing. As a balancing method, a method is generally known in which the mass of the rotational body is changed by partially cutting off the outer circumferential surface or the inner circumferential surface of the rotational body by using a cutting tool such as a drill or a router, thus performing fine adjustments of the balance.

[0005] However, balancing is performed by cutting in the above-stated manner after conducting the anti-corrosion process, and a portion of the anti-corrosive film coated on the surface of the rotational body is removed by the cutting tool such as a drill or a router. Therefore, corrosion develops in a cut off portion where the aluminum alloy of the rotational body itself is exposed due to a corrosive gas, stress corrosion cracks progress in the cut off portion due to high speed rotation of the rotational body, and in the worst case, this may lead to destruction of the rotational body, affecting the outside of the vacuum pump as well.

[0006] Further, as stated above, the aluminum alloy of the rotational body itself is exposed in the portion cut off for balancing, and if debris or the like generated by etching a wafer surface in a semiconductor manufacturing process is mixed into the inside of the vacuum pump, then the debris will adhere to the surface of the aluminum in the cut off portion, and will be deposited as a product.

[0007] In particular, the debris will be easily deposited

on the surface of the deposited product, and if chain deposition of the product on the surface of the rotational body progresses in this manner, then the clearance between the fixed side of the vacuum pump and the rotational body will become smaller. Accordingly, there is a concern that the fixed side will have critical damage when the product deposited on the rotating body contacts the fixed side.

[0008] In view of the aforementioned matters in dispute, an object of the present invention is to provide a vacuum pump in which destruction of a rotational body due to corrosion can be prevented, and in which the deposition of the product is reduced, preventing damage due to contact between the rotational body and a fixed side.

[0009] In order to achieve the aforementioned objective, a vacuum pump according to the present invention is provided with: a pump case having a gas inlet port opened in its top surface; a rotor shaft rotatably supported within the pump case; a plurality of rotor blades formed on an outer circumferential surface of a rotor that is fixed to the rotor shaft and housed within the pump case; a plurality of stator blades fixed within the pump case and positioned alternately with the plurality of rotor blades; a driving motor for rotating the rotor shaft; an anti-corrosive film layer formed on a surface of the rotor; and a balancing hole formed by partially cutting off an inner circumferential surface or an outer circumferential surface of the rotor, the vacuum pump being characterized in that anti-corrosion process is performed on the balancing hole.

[0010] The anti-corrosion process employed here means a process in which a thermosetting resin film layer is formed on a surface of the balancing hole. Synthetic resins having superior heat resistance characteristics and superior anti-corrosion characteristics, such as epoxy resins and fluorine resins, for example, can be used as the thermosetting resin.

[0011] Further, a vacuum pump according to the present invention is provided with: a pump case having a gas inlet port opened in its top surface; a rotor shaft rotatably supported within the pump case; a plurality of rotor blades formed on an outer circumferential surface of a rotor that is fixed to the rotor shaft and housed within the pump case; a plurality of stator blades fixed within the pump case and positioned alternately with the plurality of rotor blades; a driving motor for rotating the rotor shaft; and a balancing hole formed by partially cutting off an inner circumferential surface or an outer circumferential surface of the rotor; the vacuum pump being characterized in that an anti-corrosive film layer is formed on a surface of the rotor.

[0012] Embodiments of the present invention will now be described by way of further example only and with reference to the accompanying drawings, in which:-

Fig. 1 is a vertical cross sectional diagram showing the structure of a first embodiment of a vacuum

pump according to the present invention.

Fig. 2 is a blow-up cross sectional diagram of the main portions of the vacuum pump shown in Fig. 1, and is a diagram for explaining an example of forming balancing holes in a rotor using a cutting tool.

Fig. 3 is a blow-up cross sectional diagram of the main portions of the vacuum pump shown in Fig. 1, and is a diagram showing a state after performing anti-corrosion process to the rotor balancing holes.

Fig. 4 is a blow-up cross sectional diagram of the main portions of the vacuum pump shown in Fig. 1, and is a diagram showing a second embodiment of an anti-corrosion process performed on the rotor balancing holes.

[0013] An embodiment of the present invention is explained in detail below with reference to the attached drawings.

[0014] Fig. 1 is a vertical cross sectional diagram showing the structure of a first embodiment of a vacuum pump according to the present invention.

[0015] As shown in Fig. 1, a vacuum pump P of this embodiment is mainly structured from a pump case 1 composed of a cylindrical portion 1-1 and a base 1-2 attached to a lower end of the cylindrical portion 1-1, and a pump mechanism portion housed in the pump case 1.

[0016] An upper surface of the pump case 1 is opened, serving as a gas inlet port 2, and a not shown vacuum container, such as a process chamber, is screwed into the gas inlet port 2 and fixed with a bolt, and an exhaust pipe that serves as a gas exhaust port 3 is formed in one side surface of a lower portion of the pump case 1.

[0017] A lower base of the pump case 1 is covered by a rear cover 1-3, and a stator column 4 is disposed above the rear cover 1-3 in a standing manner toward an inside portion of the pump case 1 and is screwed into and fixed to the base 1-2.

[0018] A rotor shaft 5 is bearing-supported in the radial direction and in the axial direction by a radial direction electromagnet 6-1 and an axial direction electromagnet 6-2, respectively, which are formed in an inside portion of the stator column 4 so that the rotor 5 passing through between both ends of the stator column 4 is able to rotate. Note that reference numeral 7 denotes a ball bearing to which a dry lubricant has been applied. The ball bearing 7 protects the rotor shaft 5 and the electromagnets 6-1 and 6-2 from contacting and supports the rotor shaft 5 when an electric power source for the magnetic bearings fails, the electromagnets not being in contact with the rotor shaft 5 during normal operation.

[0019] A rotor 8 formed in a cylindrical shape is disposed in the inside portion of the pump case 1 so as to surround the stator column 4, an upper end of the rotor 8 extends to the vicinity of the gas inlet port 2, and is fixed to the rotor shaft 5 by screwing with a bolt.

[0020] In a nearly center portion of the rotor shaft 5 in

the axial direction, a driving motor 9 composed of a high frequency motor or the like is provided between the rotor shaft 5 and the stator column 4, and the rotor shaft 5 and the rotor 8 are rotated at high speed by the driving motor 9.

[0021] Further, the pump mechanism portion of the vacuum pump P of this embodiment is housed within the pump case 1 and employs a composite type pump mechanism composed of turbo molecular pump mechanism portion P_A of upper half, and thread groove pump mechanism portion P_B of lower half, which are defined between an outer circumferential surface of the rotor 8 and an inner circumferential surface of the pump case 1.

[0022] The turbo molecular pump mechanism portion P_A is structured by rotator blades 10 that rotate at high speed and static stator blades 11 that are fixed.

[0023] That is, a plurality of processed blade shape rotor blades 10, 10, ... are formed on the outer circumferential surface of the upper half of the rotor 8 from the gas inlet port 2 side in a direction to a central rotation axis L of the rotor 8. A plurality of stator blades 11, 11, ... disposed alternately between the plurality of rotor blades 10, 10, ... are formed on the inner circumferential surface of the upper half of the pump case 1, and are fixed through spacers 12, 12, ...

[0024] On the other hand, the thread groove pump mechanism portion P_B is structured by a cylindrical surface 8a of the rotor 8 rotating at high speed and a static thread groove 13.

[0025] That is, the outer circumferential surface of the lower half of the rotor 8 serves as the flat cylindrical surface 8a, and in the inner circumferential surface of the lower half of the pump case 1 a cylindrical screw stator 14 is disposed so as to oppose the cylindrical surface 8a of the rotor 8 with a narrow gap. The thread groove 13 is carved in the screw stator 14.

[0026] Note that the thread groove 13 can be carved in the outer circumferential surface of the lower half of the rotor 8. Also, an opposing surface of the screw stator 14 provided on the inner circumference of the lower half of the pump case 1, to the rotor 8 can be formed in the flat cylindrical surface.

[0027] Incidentally, the vacuum pump P of this embodiment is used under a severe environment exposed to corrosive chlorine and fluorine sulfide gasses during semiconductor manufacturing processes, an anti-corrosive process is performed as shown in Fig. 2 for forming an even coating of an anti-corrosive film layer 15 by means of a plating, such as a nickel phosphorous oxide plating, at a thickness on the order of 10 to 20 μm on the outer circumferential surface 8a and the inner circumferential surface 8b of the rotor 8, which is formed by an aluminum alloy or the like.

[0028] Further, the following may be performed as means for performing balancing of the rotational body composed of the rotor shaft 5, the rotor 8, and the rotor blades 10 during high speed rotation: the stator blades 11 and the screw stator 14 fixed to the cylindrical portion

1-1 of the pump case 1 may be temporarily removed, and as shown in Fig. 2, balancing holes 16, 16, ... maybe formed by partially cutting off the surface of the anti-corrosive film layer 15 formed in the outer circumferential surface 8a or the inner circumferential surface 8b of the rotor 8 using a cutting tool 20 such as a drill or a router; changing the mass of the rotor 8 and performing fine adjustments of the balance of the rotational body; and then an anti-corrosion process is performed on the surface of the balancing holes 16.

[0029] The surface of the balancing holes 16 after performing the rotational body balancing is in a state in which a portion of the aluminum alloy of main body of the rotor 8 is exposed because a portion of the anti-corrosive film layer 15 coated on the surface of the outer circumferential surface 8a and the inner circumferential surface 8b of the rotor 8 is cut off, as shown in Fig. 2.

[0030] Therefore, in order to prevent stress corrosion cracking of, and deposition of the product on the surface of the aluminum alloy of the balancing holes 16, a thermosetting resin film layer 17 having superior heat resistance characteristics and superior anti-corrosion characteristics, such as an epoxy resin, a fluorine resin, or the like is formed on the surface of the balancing holes 16, as shown in Fig. 3.

[0031] The aforementioned thermosetting resin has good adhesive characteristics with respect to metallic materials and has strong adhesive force with respect to curved surfaces like the inner circumferential surface 8b and the outer circumferential surface 8a of the rotor 8, and therefore peeling due to centrifugal force of the rotational body will not occur. Further, the thermosetting resin has superior oxygen barrier characteristics, and therefore anti-corrosion process can be performed by a relatively simple method of only forming the thermosetting resin film layer 17 on the surface of the balancing holes 16.

[0032] As a method of forming the thermosetting resin film layer 17, a known spray application process using a spray gun or the like, followed by age hardening by the rotor 8 at room temperature or a required temperature may be employed, whereby conducting a uniform application at least on the surface of the aluminum alloy of the balancing holes 16 at a thickness of 10 to 20 μm .

[0033] Provided that the thermosetting resin film layer 17 is formed into a thick film, anti-corrosion performance can be increased, and corrosion of the balancing holes 16 can be prevented over a long period of time. However, by reason that manufacturing cost rises, the gap between the outer circumferential surface 8a of the rotor 8 and the screw stator 14 becomes narrower, the rotational body and the fixed side of the vacuum pump come into contact, and the fixed side is damaged, the aforementioned film thickness range is appropriate.

[0034] Further, the weight of the thermosetting resin film layer 17 after hardening and drying is set on the order of 1 to 10 mg with respect to the number of balancing holes 16, and considering the increase in weight

due to the thermosetting resin film layer 17, it is necessary to form the synthetic resin film layer 17 after performing a little excess amount of material cutting for balancing.

[0035] In accordance with the vacuum pump of this embodiment, the aluminum alloy surface of the balancing holes 16 formed in the surface of the outer circumferential surface 8a or the inner circumferential surface 8b of the rotor 8 is covered by the thermosetting resin film layer 17 as an anti-corrosion process, and therefore corrosion due to a corrosive gas does not develop in the aluminum alloy surface of the balancing holes 16, stress corrosion cracking of the balancing holes due to high speed rotation of the rotational body can be prevented, and rotor destruction due to corrosion can be prevented from happening.

[0036] Further, as stated above, the thermosetting resin film layer 17 can be formed on the aluminum alloy surface of the balancing holes 16b into a thin film as an anti-corrosion process, and deposition of the product adhering to the aluminum alloy can be reduced, and therefore damage due to contact between the rotational body and the fixed side can be prevented.

[0037] Next, a second embodiment of a vacuum pump according to the present invention is explained based on Fig. 4.

[0038] The basic structure of the vacuum pump in this second embodiment is similar to the vacuum pump shown in Fig. 1, and therefore identical reference numerals are attached to identical portions, and a detailed explanation of those portions is omitted.

[0039] The vacuum pump in this second embodiment is characterized in that the balancing holes 16 are formed by removing a portion of the inner circumferential surface 8b or the outer circumferential surface 8a of the rotor 8, and in that the corrosion prevention layer 15 is formed on the inner circumferential surface 8b and the outer circumferential surface 8a of the rotor 8, as shown in Fig. 4.

[0040] That is, in this second embodiment, a portion of the outer circumferential surface 8a or the inner circumferential surface 8b of the rotor 8 formed by the aluminum alloy or the like is removed by using the cutting tool 20 such as a drill or a router, changing the mass of the rotor 8 and performing fine adjustments of the balance of the rotational body, after which the corrosion prevention film layer 15 is uniformly coated to a thickness on the order of 10 to 20 μm by plating a nickel phosphorous alloy plating or the like, performing anti-corrosion process at the same time to the rotor 8 and to the balancing holes 16.

[0041] In accordance with the vacuum pump of this second embodiment, in addition to the effects obtained by the above stated first embodiment, the process step for forming the thermosetting resin film layer 17 for anti-corrosion process of the balancing holes 16 can be omitted, anti-corrosion process of the balancing holes 16 can be simplified, and the manufacturing costs of the

vacuum pump relating to anti-corrosion process can be lowered.

[0042] Further, the corrosion prevention film layer 15 is formed uniformly over the entire surface of the rotor 8 after performing balancing as stated above, and therefore it is not necessary to remove an excess amount of material in order to adjust the balance.

[0043] Note that although an example of applying the present invention to a turbo molecular pump is explained in the aforementioned embodiments, the present invention can also be applied, of course, to other pumps that utilize rotation of a rotating body, such as a drag pump, and it is also possible to suitably change the locations in which the balancing holes are formed for design reasons.

[0044] As explained in detail above, the following effects can be obtained in accordance with the vacuum pump according to the present invention.

(1) An effect in which corrosion due to corrosive gas does not develop on the aluminum alloy surface of the balancing holes formed in the rotor surface, stress corrosion cracking of the balancing holes due to high speed rotation of the rotational body can be prevented, and therefore, destruction of the rotor due to corrosion can be prevented from happening.

(2) An effect in which the thermosetting resin film layer can be formed as a thin film on the aluminum alloy surface of the balancing holes for the heat resistance process, and deposition of the product adhering to the aluminum alloy can be reduced, and therefore damage due to contact between the rotational body and the fixed side can be prevented.

(3) An effect in which anti-corrosion process of the balancing holes can be simplified provided that the structure is employed in which the corrosion prevention film is formed uniformly over the entire surface of the rotor after performing balancing, and manufacturing costs for the vacuum pump relating to anti-corrosion process can be reduced.

an anti-corrosive film layer formed on a surface of the rotor; and

a balancing hole formed by partially cutting off an inner circumferential surface or an outer circumferential surface of the rotor, and treated with anti-corrosion process.

2. A vacuum pump according to claim 1, wherein the anti-corrosion process comprises forming a thermosetting resin film layer on a surface of the balancing hole.

3. A vacuum pump comprising:

a pump case having a gas inlet port opened in its top surface;

a rotor shaft rotatably supported within the pump case;

a plurality of rotor blades formed on an outer circumferential surface of a rotor that is fixed to the rotor shaft and housed within the pump case;

a plurality of stator blades fixed within the pump case and positioned alternately with the plurality of rotor blades;

a driving motor for rotating the rotor shaft;

a balancing hole formed by partially cutting off an inner circumferential surface or an outer circumferential surface of the rotor; and

an anti-corrosive film layer formed on a surface of the rotor.

Claims

1. A vacuum pump comprising:

a pump case having a gas inlet port opened in its top surface;

a rotor shaft rotatably supported within the pump case;

a plurality of rotor blades formed on an outer circumferential surface of a rotor that is fixed to the rotor shaft and housed within the pump case;

a plurality of stator blades fixed within the pump case and positioned alternately with the plurality of rotor blades;

a driving motor for rotating the rotor shaft;

FIG. 1

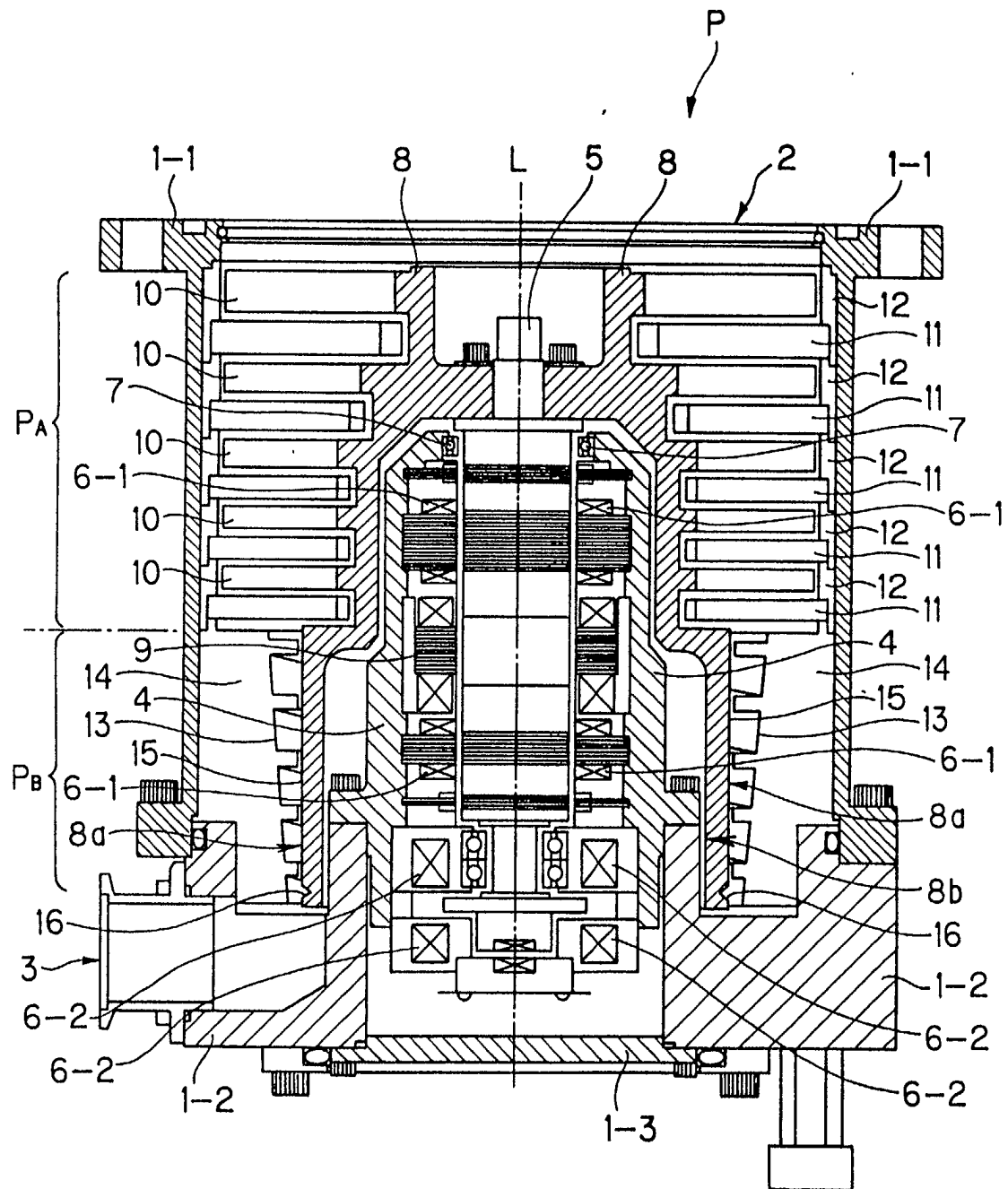


FIG. 2

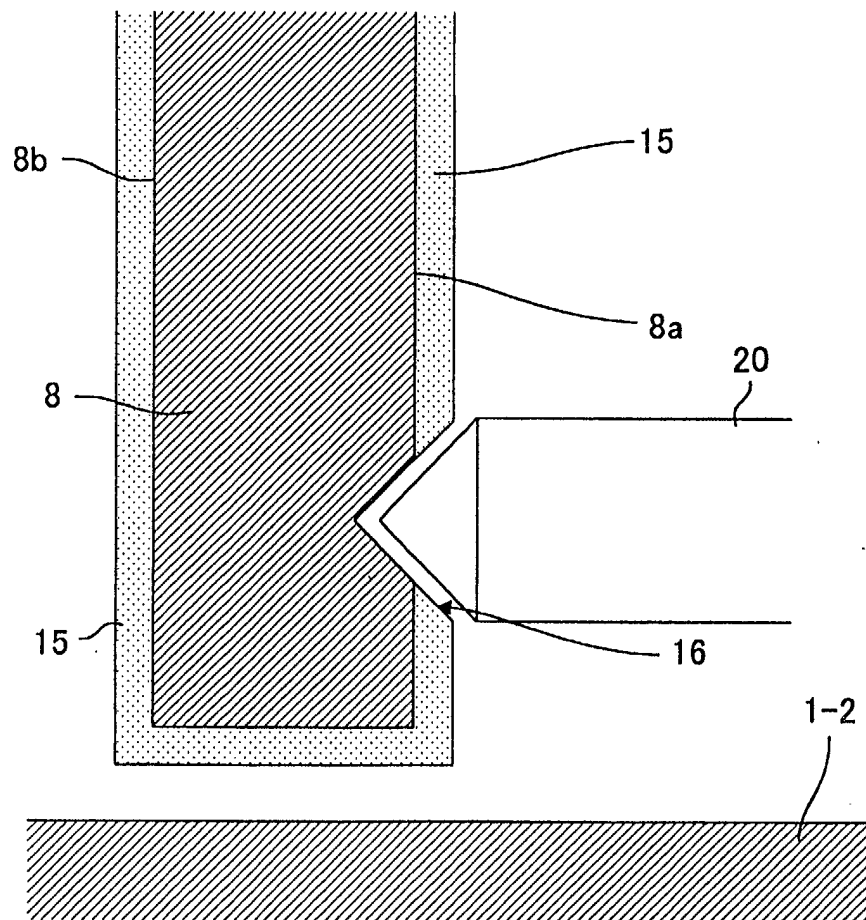


FIG. 3

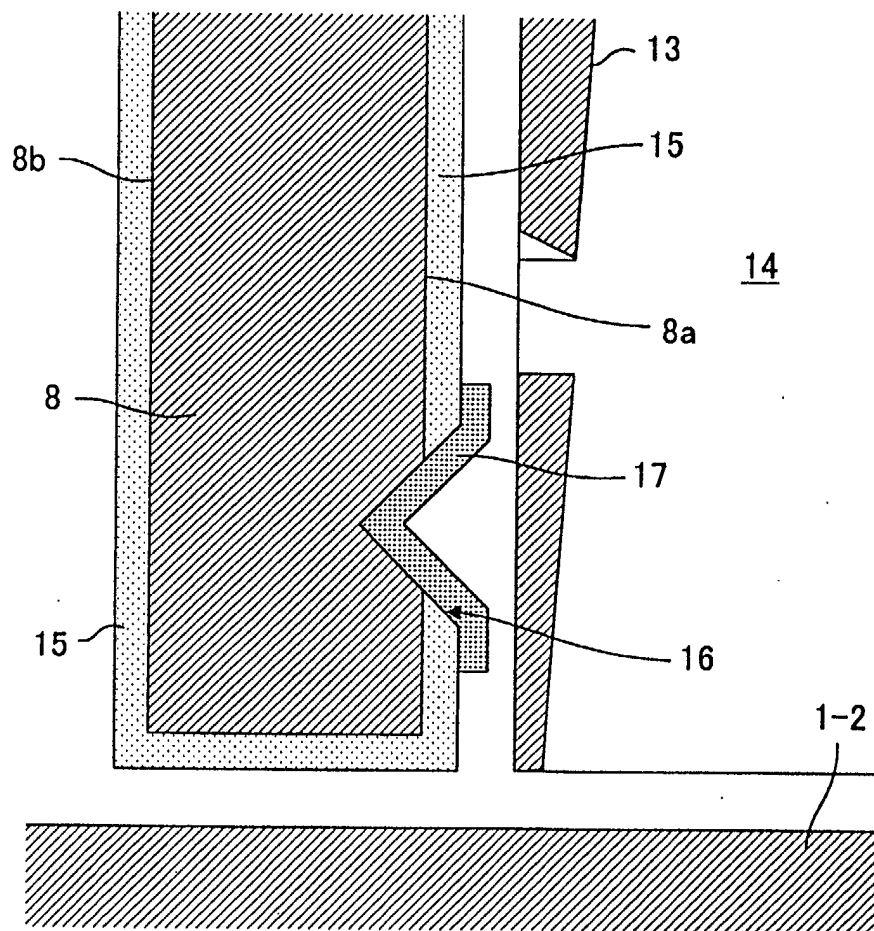
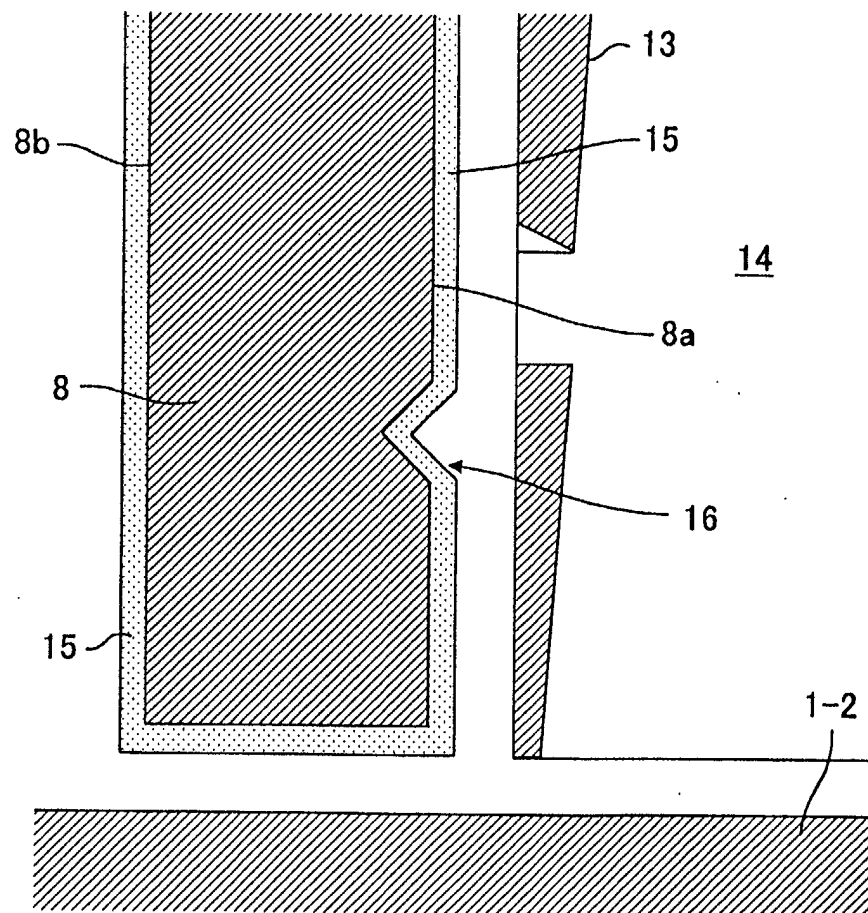


FIG. 4





European Patent
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EPO FORM 1503 03/92 (F04D01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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