

## VALVE HAVING A SEALING MEMBER

[0001] The present invention is directed to a valve having a closure member for closing a valve orifice, particularly so as to be tight against gas, in a closed position of the closure member, wherein the closure member can be moved in a closing process by at least one actuator starting from a first position of maximum opening at least along a first partial distance with a linear movement component in direction of its closed position, and the actuator carries out a closing stroke with a linear stroke direction for a movement of the closure member with this movement component.

[0002] Generic valves are used, for example, in semiconductor fabrication or semiconductor machining, to carry out individual machining steps in a gastight manner in closed environments which are substantially emptied of air, i.e., vacuum environments. Often, these valves are also called vacuum valves. They are also frequently referred to as slide valves because the closure member of the valve is displaced along its path from the maximum open position to the closed position in a linear manner at least partially. As a matter of principle in such valves, care must be taken that a seal which is usually arranged at the closure member, or at the seat surface of the valve corresponding to it, is not loaded transverse to its longitudinal direction after the closure member has made contact with the sealing surface. Such shear stresses on the seals are generally acknowledged as being very detrimental to the longevity of the seal. To prevent this, various type of closure members have been developed in the prior art which are movable at least partially in a linear motion from the maximum open position to the closed position. A first group of closure members is constructed so as to be substantially wedge-shaped so that a force component presses the closure member against the seat surface perpendicular to the seat surface at the end of the closing movement of the closure member due to the wedge effect. Closure members in this type of embodiment are shown, e.g., in US 4,921,213 and US 7,011,294. In other generic valves, the closure member is initially displaced linearly in a displacement direction

by an actuator for closing the valve until the closure member is in a position in which it lies opposite to the valve orifice but so as to be raised from the valve seat. This is followed by a movement with another movement component usually oriented perpendicular to the seat surface so that the closure member is pressed against the seat surface of the valve housing. The second part of the closing movement in such slide valves is achieved in different ways. US 6,629,682, for example, shows a generic valve in which the closure member is pressed against the seat surface of the valve housing by a tilting movement by means of another actuator. With respect to this type of valve, in which the closure member in its entirety executes an L-shaped or J-shaped movement, other variants are also known in which the closure member is pressed against the seat surface by tilting members. A design of this type is shown, e.g., in DE 32 24 387.

[0003] Other variants of closure members known from the prior art are moved linearly exclusively in one direction when moving from the maximum open position into the closed position. In this case, the seat surface of the valve body is correspondingly arranged perpendicular to the movement direction of the closure member. An example is disclosed in US 6,685,163.

[0004] It is conventional in the prior art to realize the linear movement of the closure member by means of a – usually pneumatic – piston-cylinder unit. The piston rod of this unit generally acts directly on the closure member. This has two drawbacks. First, the closing speed and opening speed that can be realized by means of these pneumatic actuators is not as high as would be desirable especially in the first movement phase. Second, the dimensions and design of these actuators must be very large in order to provide the desired closing pressures in the closed position of the closure member.

[0005] JP 6-241344 discloses a solution in which the closing stroke of the actuator, which is likewise constructed as a piston-cylinder unit, is carried out parallel to the linear closing movement of the valve body. To improve the speed and available contact pressing pressures, this reference discloses connecting the actuator to the closure member by means of gears driven by a toothed rack and arms which are eccentrically articulated at the latter.

However, the construction shown in this reference is relatively complicated and requires many parts.

[0006] It is the object of the invention to provide a simple design with as few moving parts as possible for a valve of the generic type in which the fastest possible closing stroke can be realized and high closing pressures can be achieved in the closed position with actuators having relatively small dimensions.

[0007] This object is met in that the actuator is so arranged in relation to the closure member that an angle diverging from  $0^\circ$  and  $180^\circ$  is provided between the linear movement component of the closure member along the first partial distance proceeding from the first position of maximum opening and the linear stroke direction of the actuator.

[0008] By means of the arrangement of the actuator in relation to the closure member per the invention, relatively simple but efficient transmission mechanisms can be realized which make it possible to realize a high closing speed of the closure member and also sufficiently high closing forces in the closed position with comparatively small actuators. In the maximum open position, the valve orifice to be closed in the closed position is advantageously no longer covered at all by the closure member. Accordingly, when opened to the maximum degree, the closure member preferably releases the valve orifice completely or fully uncovers the valve orifice. In certain applications, however, it is also sufficient that the closure member uncovers at least 70% of the surface of the valve orifice, preferably at least 85% of the valve orifice, in the maximum open position.

[0009] For the purpose of an optimal generation of force, it is advantageous to provide an angle between  $45^\circ$  and  $135^\circ$ , preferably an angle between  $80^\circ$  and  $100^\circ$ , between the linear movement component of the closure member and the linear stroke direction of the actuator.

[0010] In especially preferred constructional variants, an angle of  $90^\circ$ , i.e., a right angle, is provided between the linear movement component of the closure member and the linear stroke direction of the actuator.

[0011] The directions of the linear movement components and the linear stroke direction are advantageously given by respective correspondingly shaped guides.

[0012] In preferred variants for converting the linear stroke movement of the actuator into a closing movement with a linear movement component, at least one arm for transmitting the closing stroke of the actuator to the closure member is rotatably connected to the actuator by a first articulation point and to the closure member by a second articulation point.

[0013] The closure member can be rotatably connected directly to the corresponding arm. However, in gastight valves in particular, more preferable constructional variants provide an indirect articulation of the arm at the closure member in that the latter is preferably rigidly connected to at least one valve rod, and the arm is rotatably connected to the valve rod at the second articulation point. This makes it possible to guide the closure member linearly in the area of the valve rod and to seal it relative to the valve housing preferably so as to be tight against gas. In order to achieve corresponding leverage with high initial velocity during the closing movement and large forces at the end of the closing movement, the first articulation point and the second articulation point should be at a distance from one another.

[0014] The invention can be realized in principle in all of the above forms of closure members mentioned in the prior art, a common feature of which is that the closure member is movable during the closing process starting from the first position of maximum opening first along the partial distance with a linear movement component. It depends on the embodiment form of the closure member and the corresponding shape of the seat surface whether or not the closure member is moved exclusively linearly in this direction during the closing process. The invention can also be realized with closure members which are designed in such a way that, following the partial distance with a linear movement component, they can be pressed against at least one sealing seat surface with another movement component oriented at an angle diverging from 0° and 180° in relation to the linear movement component for fully achieving the closed position. Further, it is also conceivable that the closure member undergoes in the area of the above-mentioned,

preferably first, partial distance with a linear movement component an additional movement component directed perpendicular to the latter. However, closure members which are movable exclusively with a linear movement component in one direction along the, preferably first, partial distance have a simpler construction and are easier to seal.

[0015] Further details and features of the invention are indicated in the following description of the drawings. The drawings show:

[0016] Figs. 1 to 6 a preferred first embodiment example of the invention; and

[0017] Figs. 7 to 10 schematic drawings of different modified embodiment forms according to the invention.

[0018] In the first embodiment example according to the invention, the closure member 3 is constructed in the form of a valve plate 15. During the movement from the maximum open position shown in Fig. 1 to the closed position shown in Figs. 2 and 3, the valve plate 15 exclusively executes a linear movement with the movement component in direction 22. The opening stroke is carried out correspondingly in the direction opposite to that indicated by arrow 22. In this embodiment example, the seat surface 14 is arranged at the valve housing 2. It is constructed in the manner thoroughly described and shown in US 6,685,163 which is referred to in this regard and which is incorporated in the disclosure of the present application by reference.

[0019] The valve orifice 1 is shown in the maximum open position in Fig. 1. This valve orifice 1 is closed by means of the closure member 3. In this embodiment example, the closure member 3 or valve plate 15 is rigidly connected to two valve rods 8. In this instance, these valve rods 8 are guided linearly in a gastight valve rod guide 9, known per se. An arm or lever 5 is rotatably articulated, respectively, at the end of the valve rods 8 opposite from the closure member 3 by the second articulation point 7. The first articulation points 6 are located at the respective ends of the arms 5 opposite to articulation point 7. The arms 5 are rotatably connected to the actuator 4 by means of these articulation points 6. This connection is realized in this variant by means of a slide 16 which can be moved by the actuator 4 between the position shown in Fig. 1 and the

stroke direction 23 shown in Fig. 3 and in the opposite direction when opened. In the preferred embodiment form shown in this instance, the actuator 4 is constructed as an electromagnetic linear drive 13. Drives of this kind are known, per se. The actuator guide 12 is provided for supporting the forces to be transmitted via the arms 5 in direction 22 and extends parallel to the movement direction 23 of the linear drive 13. The axes of rotation of the first articulation points and second articulation points 7 preferably extend vertical to directions 22 and/or 23. The longitudinal axis 26 of the valve orifice 1 shown in Fig. 4 likewise preferably extends perpendicular to directions 22 and/or 23. Further, the longitudinal axis 26 advantageously forms a normal to the plane of the valve orifice 1. As is realized in the present example, the linear movement component or direction 22 and/or the linear stroke direction 23 advantageously extend(s) parallel to the plane of the valve orifice 1.

[0020] Starting from the position of maximum opening according to Fig. 1 in which there is no overlapping of the closure member 3 and valve orifice 1 in the present example, the closure member 3 is displaced into the closed position shown in Fig. 2 by means of the displacement of the slide 16. In so doing, the arms 5 press the valve rods 8 and, therefore, the valve plate 15 down on the seat surfaces 14 of the valve housing 2. The slide 16 is supported at the guide portion 17 of the valve housing 2 by the actuator guide 12 to absorb the closing forces. Fig. 3 shows a position which is realized in a preferred embodiment example of the invention. In this closed position, the closure member 3 is held in a self-locking manner. According to the present variant, this is achieved in that the arms 5 and the first articulation points 6 are moved in stroke direction 23 over their respective top dead centers. The top dead center is located in a position in which the connections of the center points of the first articulation points 6 to the center points of the respective second articulation points 7 below the latter lie exactly on the force vectors acting on them. These lines are shown in dashes in Fig. 3 and are designated by 11. In the self-locking position shown in Fig. 3, the center points of the first articulation points 6 are moved over the top dead centers lying on lines 11.

[0021] Fig. 4 shows section line A-A in a side view of the first embodiment example. Fig. 5 shows the section associated with line A-A through the embodiment example. The sleeve-shaped portion 18 of the electromagnetic linear drive 13 and the core rod 19 enclosed by this sleeve-shaped portion 18 are shown in the area of the electromagnetic linear drive 13. The electromagnetic coils of the linear drive 13, which are not shown explicitly, are advantageously arranged in the sleeve-shaped portion 18, while permanent magnets are provided in the core rod 19 as is known, per se. This facilitates the electrical connection of the electromagnets arranged in the sleeve-shape portion. The ball bearings 20 provided in the sleeve 25 which ensure the lowest possible losses through frictional forces during the displacement of the slide 16 are indicated in the area of the actuator guide 12.

[0022] Fig. 6 shows, in addition, a perspective view of the rear side of the embodiment example remote of the closure member 3.

[0023] In addition to other embodiment forms, a possible modification of the described embodiment example could consist in varying the number of arms 5 and valve rods 8 provided. It is also possible to provide only one valve rod and only one arm 5 as well as a plurality of these structural component parts. The invention also need not necessarily be realized with the preferred electromagnetic linear motor 13. Instead of this, pneumatic or hydraulic piston-cylinder units or electric motors carrying out a rotational movement can also be provided. Devices known from the prior art for converting a rotational movement into the linear stroke movement 23 must then be provided for converting the rotational movement of the electric motor. For example, these devices can be spindle gear units or rack and pinion gear units, known per se. The spindles or toothed racks then carry out a linear movement in direction 23 relative to the electric motor and the rest of the gear unit in a corresponding manner. Stepper motors are preferably used as electric motors in these variants.

[0024] Fig. 7 shows schematically how so-called toggle levers can be realized within the meaning of the invention using additional arms 5. The advantage of these toggle levers is that the forces acting opposite to direction 22 need no longer be absorbed by the linear

drive 13 or a linear actuator guide 12, not shown in Fig. 7, but rather can be introduced at fixed points 10. These fixed points 10 could be arranged, e.g., at the valve housing 2 or other correspondingly statically fixed structural component parts. As is shown in Fig. 7, the push rod 21 which is displaceable in direction 23 and in the opposite direction by the linear drive 13 is rotatably articulated at the first articulation points 6 of the two toggle levers. An arm 5 of the toggle lever leads from these points 6 to the respective second rotatable articulation point 7 at the valve rods 8. At the top, the first articulation points 6 are supported by the upper arms 5 at the fixed points 10. The fixed points 10 and the first and second articulation points 6 and 7 are constructed so as to be rotatable.

[0025] Figs. 8 to 10 show how the closure members can be shaped and moved in alternative ways in highly schematic side views of the valve orifice 1 by way of example. In the constructional variants according to Figs. 8 and 9, the closure members 3 are constructed in a wedge-shaped manner. The closing movement with a linear component in direction 22 can be realized according to the invention in the manner shown in the first embodiment example. Owing to the wedge shape of the closure members 3, these closure members 3 are pressed against the seat surface so as to be tight against gas when they are inserted into the corresponding wedge-shaped seat surfaces 14 in direction 22. The specific shape of the closure members 3 can be based on those disclosed in the drawings in US 7,011,294 or US 4,921,213, for example. As an alternative to the wedge shape, tilting members can also be used as is shown, e.g., in DE 32 24 387.

[0026] Fig. 10 schematically shows a constructional variant in which the closure member is initially moved according to the invention in direction 22 linearly downward into the area of the valve orifice 1, i.e., in direction of the closed position. The closure member 3 is then pressed against the seat surface 14 by a movement component 24 whose direction is perpendicular to movement component 22. Another actuator may be necessary in order to realize this movement component 24. This can be realized by means of a swiveling axis and an additional piston as is shown, e.g., in US 6,629,682.

[0027] The various constructional variants of the invention shown herein are particularly well suited for use as so-called vacuum valves. These are used to seal a valve

orifice in a gastight manner in such a way that it is possible to operate under vacuum in the hollow space closed in this way. By vacuum is meant a pumping out of air or gas from the hollow space which can be realized by technical means as is applied, e.g., in the machining and fabrication of semiconductor components.

Key to the Reference Numbers:

|    |                               |
|----|-------------------------------|
| 1  | valve orifice                 |
| 2  | valve housing                 |
| 3  | closure member                |
| 4  | actuator                      |
| 5  | arm                           |
| 6  | first articulation point      |
| 7  | second articulation point     |
| 8  | valve rod                     |
| 9  | valve rod guide               |
| 10 | fixed point                   |
| 11 | line                          |
| 12 | actuator guide                |
| 13 | linear drive                  |
| 14 | seat surface                  |
| 15 | valve plate                   |
| 16 | slide                         |
| 17 | guide portion                 |
| 18 | sleeve-shaped portion         |
| 19 | core rod                      |
| 20 | ball bearing                  |
| 21 | push rod                      |
| 22 | linear movement component     |
| 23 | stroke direction              |
| 24 | additional movement direction |
| 25 | sleeve                        |
| 26 | longitudinal axis             |

Patent Claims:

1. Valve having a closure member (3) for closing a valve orifice (1), particularly so as to be tight against gas, in a closed position of the closure member (3), wherein the closure member (3) can be moved in a closing process by at least one actuator (4) starting from a first position of maximum opening at least along a first partial distance with a linear movement component (22) in direction of its closed position, and the actuator (4) carries out a closing stroke with a linear stroke direction (23) for a movement of the closure member (3) with this movement component, characterized in that the actuator (4) is so arranged in relation to the closure member (3) that an angle diverging from  $0^{\circ}$  and  $180^{\circ}$  is provided between the linear movement component (22) of the closure member (3) along the first partial distance, proceeding from the first position of maximum opening, and the linear stroke direction (23) of the actuator (4).

2. Valve according to claim 1, characterized in that an angle between  $45^{\circ}$  and  $135^{\circ}$ , preferably an angle between  $80^{\circ}$  and  $100^{\circ}$ , is provided between the linear movement component (22) of the closure member (3) along the first partial distance, proceeding from the first position of maximum opening, and the linear stroke direction (23) of the actuator (4).

3. Valve according to claim 1, characterized in that an angle of  $90^{\circ}$  is provided between the linear movement component (22) of the closure member (3) along the first partial distance, proceeding from the first position of maximum opening, and the linear stroke direction (23) of the actuator (4).

4. Valve according to one of claims 1 to 3, characterized in that the linear movement component (22) and/or the linear stroke direction (23) are/is arranged parallel to a plane of the valve orifice (1).

5. Valve according to one of claims 1 to 4, characterized in that the closure member (3) is held in its closed position in a self-locking manner.

6. Valve according to one of claims 1 to 5, characterized in that at least one arm (5) for transmitting the closing stroke of the actuator (4) to the closure member (3) is rotatably connected to the actuator (3) by a first articulation point (6) and to the closure member (3) by a second articulation point (7).

7. Valve according to claim 6, characterized in that the closure member (3) is, preferably rigidly, connected to at least one valve rod (8), and the arm (5) is rotatably connected to the valve rod (8) at the second articulation point (7).

8. Valve according to claim 6 or 7, characterized in that the first articulation point (6) and the second articulation point (7) are at a distance from one another.

9. Valve according to claim 7 or 8, characterized in that the valve rod (8) is linearly guided in a, preferably gastight, valve rod guide (9).

10. Valve according to one of claims 6 to 9, characterized in that at least two arms (5) are provided for transmitting the closing stroke of the actuator (4) to the closure member (3), wherein the two arms (5) are rotatably connected to the actuator (4) at the first articulation point (6), and one of the arms (5) is rotatably connected to the closure member (3) at the second articulation point (7), and the other arm (5) is rotatably supported at a fixed point (10).

11. Valve according to one of claims 6 to 10, characterized in that the arm(s) 5 can be moved into the closed position of the closure member (3) over a top dead center and remain(s) in a self-locking manner in the position moved over the top dead center.

12. Valve according to one of claims 1 to 11, characterized in that the actuator (4) is (are) guided linearly by an actuator guide (12).

13. Valve according to one of claims 1 to 12, characterized in that the actuator (4) has a linear drive (13), preferably an electromagnetic linear drive (13).

14. Valve according to one of the preceding claims, characterized in that it is a slide valve in which the closure member (3) can slide in front of the valve orifice (1) with a movement having a linear component.

15. Valve according to one of the preceding claims, characterized in that the closure member (3) carries out exclusively a linear movement with only one movement component (22) during the closing process.

16. Valve according to one of claims 1 to 14, characterized in that the closure member (3) is movable starting from the first position of maximum opening along the first partial distance with a linear movement component (22) in direction of its closed position and can be pressed against at least one sealing seat surface (14) with another movement component (22) oriented at an angle diverging from 0° and 180° in relation to the linear movement component (24) for fully achieving the closed position.