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(54) **MULTILAYER VALVE STRUCTURES, METHODS OF MAKING, AND PUMPS USING SAME**

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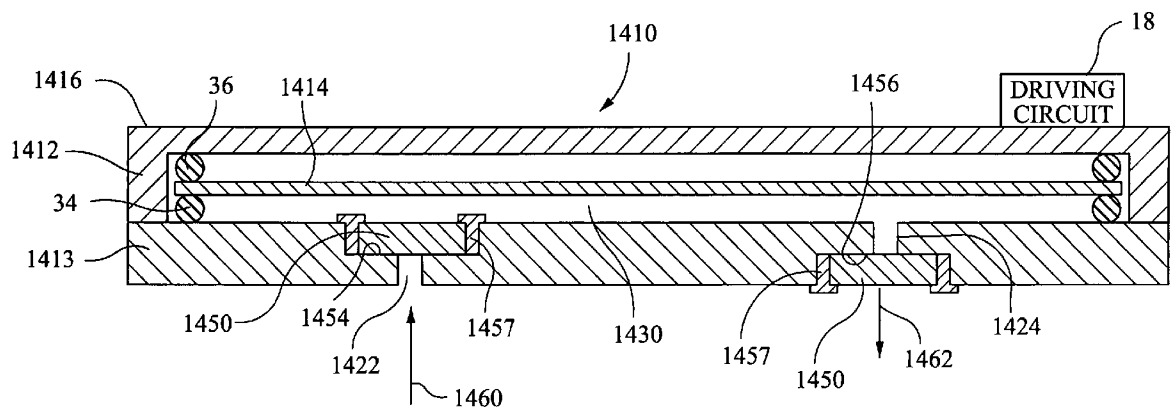
(57) **ABSTRACT**

A multilayer valve subassembly (**50**) comprises an interface layer (**60**) having an interface layer flap (**62, 64**); a cover layer (**70**) having a cover layer flap (**72, 74**); and, an intermediate layer (**80**) positioned between the interface layer and the cover layer. The intermediate layer (**80**) has an intermediate layer flap (**82, 84**) essentially aligned with the interface layer flap and the cover layer flap. A first bond (**102**) adheres the cover layer (**70**) to the interface layer (**60**); a flap bond (**92, 94**) seals the interface layer flap (**82, 84**) between the cover layer flap (**72, 74**) and the interface layer flap (**62, 64**) and thereby forms a multilayer valve flap (**52, 54**) which is insulated from fluid which travels through the valve. In an example embodiment, the each of the interface layer flap, the cover layer flap, and the interface layer flap has a substantially U-shape. Preferably the interface layer is not in contact with the first bond or the second bond and has a size that permits the interface layer to float in a sandwich pocket formed between the interface layer and the cover layer.



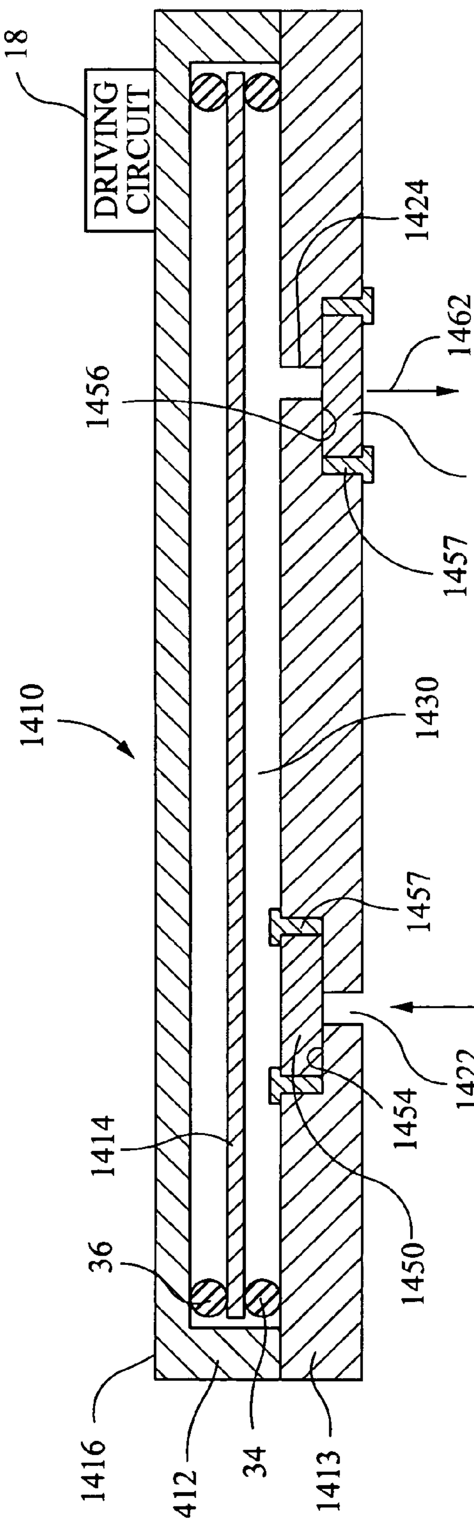


Fig. 1A

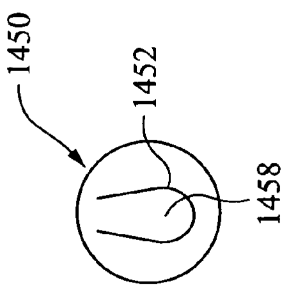


Fig. 1B

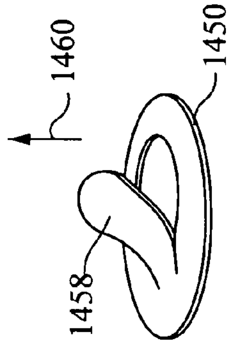


Fig. 1C

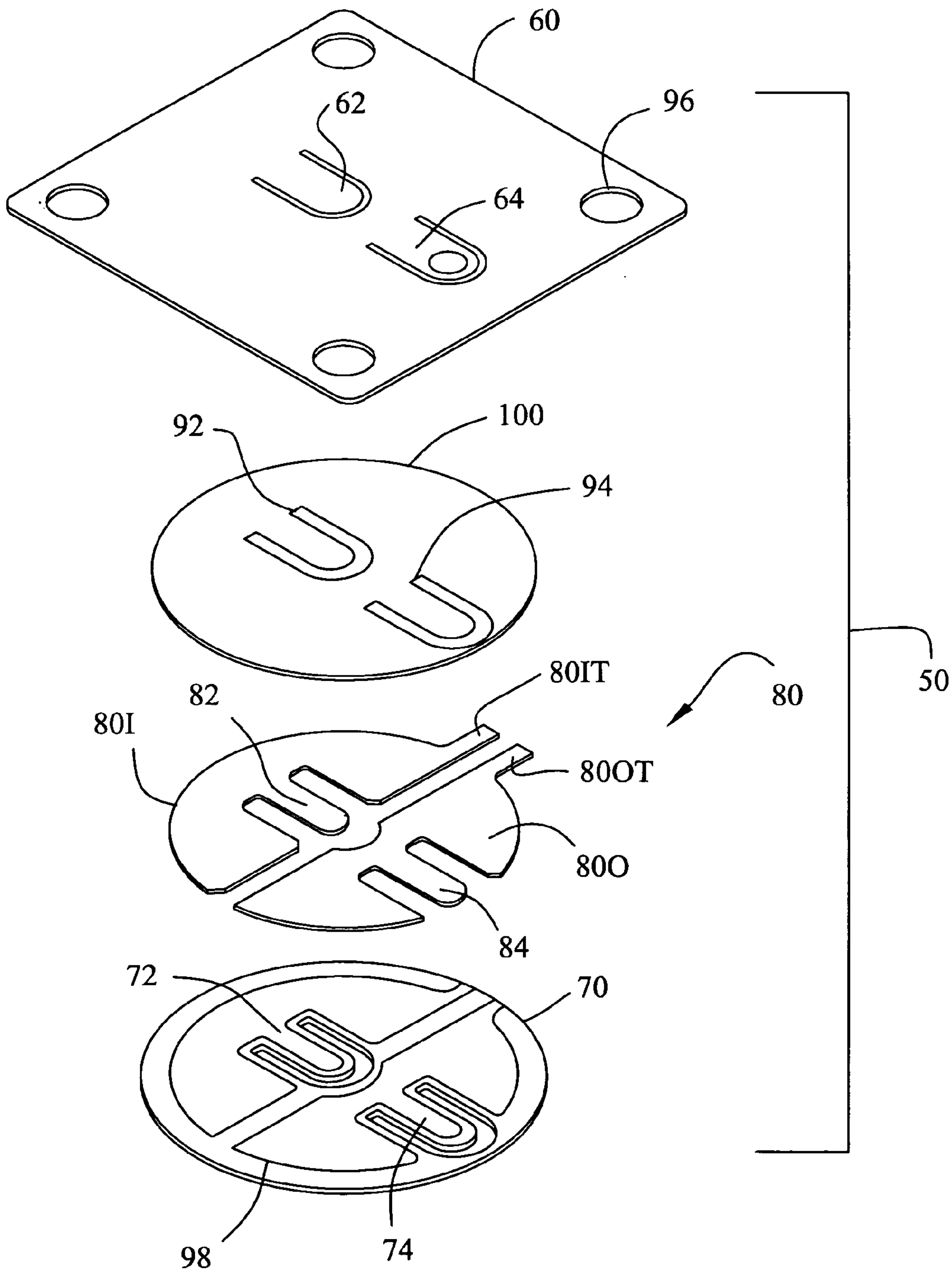


Fig. 2

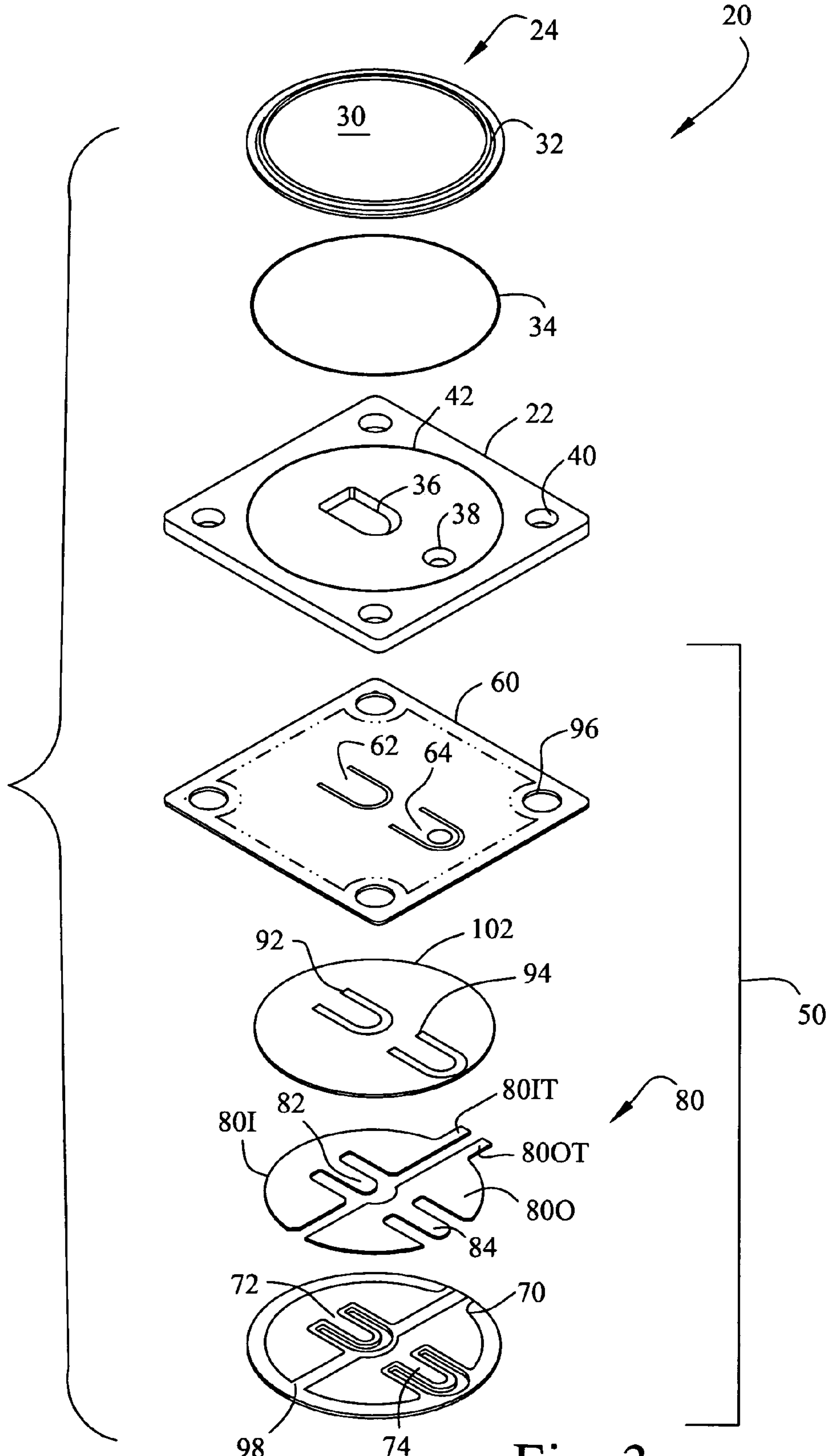

24
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Fig. 3

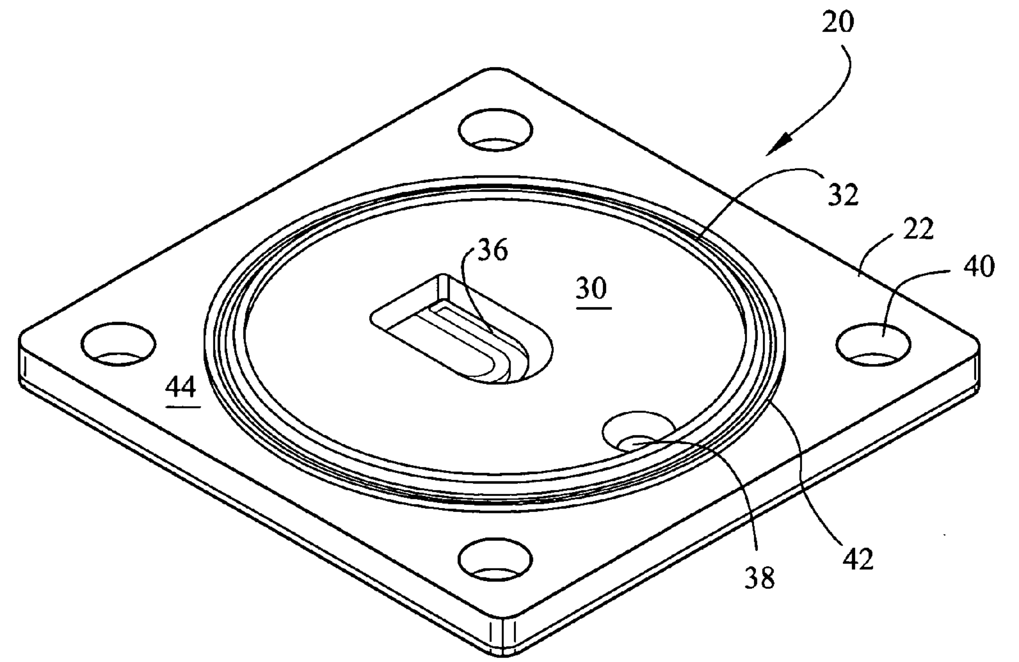

Fig. 4

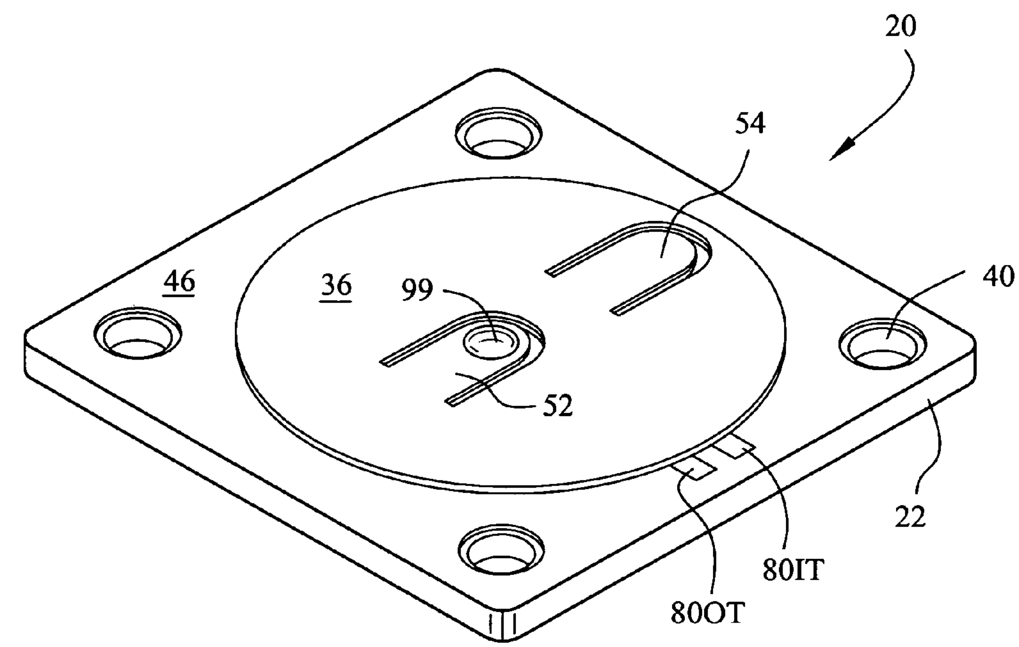

Fig. 5

MULTILAYER VALVE STRUCTURES, METHODS OF MAKING, AND PUMPS USING SAME

BACKGROUND

[0001] This application is related to simultaneously-filed United States Patent Application Serial Number (Attorney Docket 4209-54), entitled ELECTROMAGNETICALLY BONDED PUMPS AND PUMP SUBASSEMBLIES AND METHODS OF FABRICATION, which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

[0002] The present invention pertains to valves suitable for use in handling fluids, such as a valve for use in a fluid pump, for example, and pumps which utilize such valves.

RELATED ART AND OTHER CONSIDERATIONS

[0003] Valves have myriads of uses, and are particularly employed in the handling of fluids. For example, when fluids are being pumped by a pump, typically the pump has an inlet port and an outlet port, one or both of which are selectively opened and closed by a valve, or other wise have a valve associated therewith.

[0004] U.S. patent application Ser. No. 10/388,589, filed Mar. 17, 2003, entitled "PIEZOELECTRIC ACTUATOR AND PUMP USING SAME, incorporated herein by reference in its entirety, shows various examples of piezoelectric pumps. In the course of disclosing piezoelectric pump structures, flapper valve structures are also shown for placement in a seat of one or more of an inlet port and an outlet port of a pump chamber. **FIG. 1A** illustrates an example pump **1410** in which flapper valves, shown in more detail in **FIG. 1B** and **FIG. 1C**, are situated.

[0005] The diaphragm pump **1410** of **FIG. 1A** comprises pump body **1412** for at least partially defining a shallow cylindrical pumping chamber **1430**. The pumping chamber **1430** has an inlet port **1422** and an outlet port **1424**. Pump body **1412** has a body base **1413** and a body cover **1416**. The pump **1410** has a diaphragm **1414** situated in the pumping chamber **1430**. The diaphragm **1414** sits on a pumping chamber sealing washer **34**. The circular periphery of diaphragm **1414** is sandwiched between pumping chamber sealing washer **34** and O-ring seal **36**.

[0006] The diaphragm **1414** acts upon a fluid in the pumping chamber **1430**. Preferably action of the diaphragm **1414** is in response to application of an electromagnetic field to a piezoelectric element. The piezoelectric element may actually comprise the diaphragm **1414** (in the manner of piezoelectric wafer **38** comprising actuator **14** in **FIG. 3**, for example). Alternatively, the diaphragm **1414** may be mechanically connected to a piezoelectric member which moves, and which thereby causes the diaphragm **1414** to move, in response to application of the electromagnetic field.

[0007] At least one, and preferably both, of inlet port **1422** and outlet port **1424** of the pump **1410** of **FIG. 1A** is provided with a flapper valve **1450**. Each flapper valve **1450** is a thin wafer, preferably circular in shape (see **FIG. 14B**), having an arcuate cut **1452** formed therein.

[0008] For inlet port **1422**, flapper valve **1450** is situated in a recessed seat **1454** provided on a chamber-facing surface of body base **1413**. For outlet port **1424**, flapper valve **1450** is situated in a recessed seat **1456** on a chamber-opposing face of body base **1413**. The flapper valves **1450** are held in place in their respective recessed seats **1454** by a retainer element **1457** which is pressed into place around the edges of the flapper valve **1450**.

[0009] Preferably each flapper valve **1450** is a thin silicon wafer. In one implementation, the flapper valve **1450** has a diameter of about 0.37 inch and a thickness of about 0.002 inch. As shown in **FIG. 1B**, the arcuate cut **1452** is a substantially U-shaped cut. In the illustrated implementation, the arcuate cut **1452** extends along 0.25 inch of the diameter of flapper valve **1450**. The arcuate cut **1452** serves to form a flexible flapper **1458** which is shaped somewhat as a peninsula in the interior of flapper valve **1450**. The flapper **1458** of flapper valve **1450** has a modulus which forces the flapper valve **1450** to close after the piezoelectric element has functioned to fill the chamber **1430**, but which also causes automatic closure of valve **1450** without requiring the pressure of the piezoelectric element for the closure. For example, considering a flapper valve **1450** installed in inlet port **1422**, when the diaphragm **1414** moves to draw fluid into pumping chamber **1430** in the direction depicted by arrow **1460** in **FIG. 1C**, the flexible flapper **1458** flexes or moves also in the direction of arrow **1460**. Conversely, considering the flapper valve **1450** in outlet port **1424**, when the diaphragm **1414** is actuated to drive fluid out of diaphragm **1414** in the direction depicted by arrow **1464**, the flexible flapper **1458** of the flapper valve **1450** in outlet port **1424** also flexes in the direction of arrow **1462**.

[0010] The flapper valve **1450** is particularly beneficial for replacing metal check valves or the like in small pumps. Advantageously, the thin flapper valve **1450** facilitates overall a thinner pump. Whereas conventional metal check valves have a thickness on the order of about 0.093 inch, the flapper valve **1450** has a thickness of about 0.002 inch. In the illustrated implementation, such small thickness for flapper valve **1450** means that the pump **1410** can have an overall thickness (in the direction of arrow **1460**) as small as 0.125 inch. As such, the pump **1410** is particularly advantageous for use in fuel cells, fountains and cooling solutions as well as drug infusion pumps in the medical industry, or in any environment in which small but accurate flows are required. The entire pump **1410** can be either molded in ceramics, injection molded in plastic or milled in metal or plastic.

[0011] The foregoing illustrates just one employment of one example embodiment of a valve in a fluid-handling environment. It is important that fluid-handling valves remain structurally stable for suitably responding in the course of valve operation to stimuli for opening or closing the valves, such as fluidic pressure or even electrical signal(s). However, the fluid being handled can have deleterious or corrosive effect upon exposed valve structure, particularly if valve structure provided for stability is metallic.

[0012] What is needed, therefore, and an object of the present invention, is a fluid-handling valve which has suitable resilience to facilitate valve opening, stability to maintaining valve closing when required, and substantial structurally immunity to the fluids.

BRIEF SUMMARY

[0013] A multilayer valve subassembly comprises an interface layer having an interface layer flap; a cover layer having a cover layer flap; and, an intermediate layer positioned between the interface layer and the cover layer. The intermediate layer has an intermediate layer flap essentially aligned with the interface layer flap and the cover layer flap. A first bond adheres the cover layer to the interface layer; a flap bond seals the interface layer flap between the cover layer flap and the interface layer flap and thereby forms a multilayer valve flap which is insulated from fluid which travels through the valve.

[0014] In an example embodiment, the each of the interface layer flap, the cover layer flap, and the interface layer flap has a substantially U-shape.

[0015] Preferably the interface layer is not in contact with the first bond or the second bond and has a size that permits the interface layer to float in a sandwich pocket formed between the interface layer and the cover layer. In one example implementation, the intermediate layer serves as a stabilizing or stiffener layer and comprises, e.g., an electroconductive metal which is sealed by the first bond and the flap bond for protection from fluid. In an example implementation, the cover layer comprises an elastomer.

[0016] In another example embodiment, the interface layer has an interface layer first flap and an interface layer second flap. The intermediate layer has an intermediate layer first flap and an intermediate layer second flap. The cover layer has a cover layer first flap and a cover layer second flap. A first flap bond bonds the first flap of the interface layer to the first flap of the cover layer whereby the first flap of the intermediate layer sandwiched between the first flap of the interface layer and the first flap of the cover layer forms a first valve flap. A second flap bond bonds the second flap of the interface layer to the second flap of the cover layer whereby the second flap of the intermediate layer sandwiched between the second flap of the interface layer and the second flap of the cover layer forms a second valve flap. Preferably but not necessarily, the intermediate layer first flap and the intermediate layer second flap are electrically isolated. In an illustrated embodiment, the first valve flap is centrally formed with respect to the interface layer, the intermediate layer, and the cover layer.

[0017] When utilized in conjunction with a pump, a multilayer structure formed by the bonding of the cover layer to the interface layer has a footprint which is substantially equal to a pump footprint. The multilayer structure formed by the bonding of the cover layer to the interface layer can have various shapes.

[0018] In one example mode of fabrication, at least one of the first bond and the second bond is an electromagnetic bond formed by absorption of electromagnetic energy. Other bonding techniques are also possible, such as use of adhesives, fasteners, heat treatment, for example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments as illustrated in the accompanying drawings in which reference characters refer to the same parts throughout the various views. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

[0020] **FIG. 1A** is a schematic cross sectional front view of a thin chamber pump according to an example embodiment.

[0021] **FIG. 1B** is top view of a flapper valve included in the pump of **FIG. 1A**.

[0022] **FIG. 1C** is a diagrammatic perspective view of an open flapper valve included in the pump of **FIG. 1A**.

[0023] **FIG. 2** is an exploded view showing structure of and steps for fabricating a valve subassembly for a pump.

[0024] **FIG. 3** is an exploded view showing structure of and steps for fabricating a second example embodiment of a pump according to electromagnetic bonding technology.

[0025] **FIG. 4** is a top isometric view of the pump fabricated by the steps of **FIG. 3**.

[0026] **FIG. 5** is a top isometric view of the pump fabricated by the steps of **FIG. 3**.

DETAILED DESCRIPTION OF THE DRAWINGS

[0027] In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the present invention. However, it will be apparent to those skilled in the art that the present invention may be practiced in other embodiments that depart from these specific details. In other instances, detailed descriptions of well-known devices, circuits, and methods are omitted so as not to obscure the description of the present invention with unnecessary detail.

[0028] **FIG. 2** illustrates, in exploded format, both structure of and steps for fabricating a valve subassembly **50**. The valve subassemblies described herein are advantageously suited for use with a fluid pump, but can also be utilized in other fluid handling apparatus and environments.

[0029] Valve subassembly **50** comprises a pump interface layer **60** having an interface layer inlet flap **62** and an interface layer outlet flap **64**; a subassembly cover layer **70** having a cover layer inlet flap **72** and a cover layer outlet flap **74**; and, an intermediate layer **80** positioned between interface layer **60** and cover layer **70**, intermediate layer **80** having an intermediate layer inlet flap **82** and an intermediate layer outlet flap **84**. The intermediate layer **80** may serve as a stabilizing or stiffener layer, and can comprise an electroconductive metal. The cover layer may be an elastomer, for example.

[0030] An inlet valve weld or seam **92** bonds inlet flap **62** of interface layer **60** to inlet flap **72** of cover layer **70** for forming inlet valve **52**. Thus, inlet valve **52** comprises inlet flap **82** of intermediate layer **80** sandwiched between inlet flap **62** of interface layer **60** and inlet flap **72** of cover layer **70**. Similarly, an outlet valve weld or seam **94** bonds outlet flap **64** of interface layer **60** to outlet flap **74** of cover layer **70** for forming outlet valve **54**. Accordingly, outlet valve **54** comprises outlet flap **84** of intermediate layer **80** sandwiched between outlet flap **64** of interface layer **60** and outlet flap **74** of cover layer **70**. The inlet valve weld or seam **92** and outlet valve weld or seam **94** are illustrated in exploded fashion in

FIG. 2 for providing an understanding of the position and shape of the respective seams.

[0031] As shown in **FIG. 2**, in some example implementations intermediate layer **80** may comprise two discrete and separated segments, e.g., intermediate layer segment **80**I and intermediate layer segment **80**O. The intermediate layer segment **80**I bears intermediate layer inlet flap **82**, the intermediate layer segment **80**O bears intermediate layer outlet flap **84**. A tab **80**IT is provided at a circumference portion of intermediate layer segment **80**I, and similarly a tab **80**OT is provided at a circumference portion of intermediate layer segment **80**O. The tabs **80**IT and **80**OT may be used as electrical leads in an implementation in which the segments of the intermediate layer **80** are metallic and are connected to receive an electrical signal. In other embodiments, rather than having two discrete and separated segments there is but one unitary segment.

[0032] In a variation of the illustrated embodiment, one or both of intermediate layer inlet flap **82** and intermediate layer outlet flap **84** can each have mounted or overlaid thereon a piezoelectric material so that one or both of inlet valve **52** and outlet valve **54** can function as active valves. The structure and operation of such an active valve arrangement is understood from U.S. patent application Ser. No. 11/024,937, filed Dec. 30, 2004, which is incorporated by reference herein in its entirety.

[0033] Intermediate layer **80**, or the segments comprising intermediate layer **80**, is/are thus embedded between two other layers, which preferably are elastomer layers, so that intermediate layer **80** (or the segments thereof) is/are sealed between pump interface layer **60** and subassembly cover layer **70**. This may be particularly beneficial in an implementation in which, for example, the interface layer is a metallic layer. Moreover, depending on tolerances, the intermediate layer **80** may even have the capability of slightly floating within a pocket formed by the welding of pump interface layer **60** and subassembly cover layer **70**.

[0034] The valves **52**, **54** (which are comprised of the respective interface layer flaps **62**, **64**; the respective intermediate layer flaps **82**, **84**; and the respective cover layer flaps **72**, **74**) can have any convenient shape. In the illustrated example, each flap and thus the valves **52**, **54** have an essentially U shape. Thus, the respective flaps may be formed by a U-shaped cut out in the respective layer. Preferably, in order to provide floating positioning of intermediate layer **80** between pump interface layer **60** and subassembly cover layer **70**, intermediate layer inlet flap **82** and intermediate layer outlet flap **84** are slightly smaller than the respective flaps **62**, **72** and **64**, **74**, with which they are aligned. The flaps of the different layers are aligned with respect to a width direction of the layers.

[0035] The shapes of the layers comprising valve subassembly **50**, e.g., pump interface layer **60**, subassembly cover layer **70**, and intermediate layer **80** are illustrated as being essentially circular. However, in other embodiments layers of differing shapes can be utilized.

[0036] The subassembly cover layer **70** may have alignment marks or indentations **98** thereon to serve as a template or guide for placement of intermediate layer **80**. Such alignment marks or indentations **98** essentially are an image of intermediate layer **80**, or segments comprising intermediate layer **80**.

[0037] In addition to illustrating the example structure of valve subassembly **50**, **FIG. 2** also depicts basic, example steps for fabricating the valve subassembly **50**. Forming valve subassembly **50** comprises three basic steps. A first such step comprises forming at least one (and preferably two) flaps in each of the interface layer **60** (e.g., interface layer inlet flap **62** and interface layer outlet flap **64**), the intermediate layer **80** (e.g., intermediate layer inlet flap **82** and intermediate layer outlet flap **84**), and cover layer **70** (e.g., cover layer inlet flap **72** and cover layer outlet flap **74**). As such, interface layer **60** has an interface layer first flap **62** and an interface layer second flap **64**; intermediate layer **80** has an intermediate layer first flap **82** and an intermediate layer second flap **84**; and, cover layer **70** has a cover layer first flap **72** and a cover layer second flap **74**.

[0038] A second step involves bonding the first flap **62** of the interface layer **60** to the first flap **72** of the cover layer **70** for forming a first valve flap or inlet valve **52**, the first valve flap or inlet valve **52** comprising the first flap **82** of the intermediate layer **80** sandwiched between first flap **62** of interface layer **60** and first flap **72** of cover layer **70**. Such bonding for forming inlet valve **52** is represented by inlet valve weld or seam **92** shown in **FIG. 3**. As mentioned above, the intermediate layer inlet flap **82** is preferably sized to be narrower than interface layer inlet flap **62** and cover layer inlet flap **72**, with the result that inlet valve weld or seam **92** does not contact intermediate layer inlet flap **82**.

[0039] For two valve embodiments, the second step also includes bonding second flap **62** of interface layer **60** to second flap **72** of cover layer **70** for forming a second valve flap or outlet valve **54**, the second valve flap or outlet valve **54** comprising second flap **84** of intermediate layer **80** sandwiched between second flap **64** of interface layer **60** and second flap **74** of cover layer **70**. Such bonding for forming outlet valve **54** is represented by outlet valve weld or seam **94** shown in **FIG. 2**. In like manner as described above, the intermediate layer outlet flap **84** is preferably sized to be narrower than interface layer outlet flap **64** and cover layer outlet flap **74**, with the result that outlet valve weld or seam **94** does not contact intermediate layer outlet flap **84**.

[0040] The third step of forming valve subassembly **50** comprises sealing the periphery of subassembly cover layer **70** to pump interface layer **60**, thereby encasing intermediate layer **80** between subassembly cover layer **70** and pump interface layer **60** so that fluid will not intrude to reach intermediate layer **80**. The step of bonding periphery of subassembly cover layer **70** to pump interface layer **60** can occur simultaneously with the preceding step of bonding the flaps. At this point, the valve subassembly **50** is now substantially complete as a stand alone part or subassembly.

[0041] The bonding included in fabrication of the valve subassembly **50** can be performed in diverse manners, such as electromagnetic bonding, adhesive bonding, heat bonding, mechanical fasteners, just to name a few.

[0042] The bonding included in the second step can be performed, for example, by directing a beam of electromagnetic energy in the pattern depicted by inlet valve weld or seam **92** and electromagnetic outlet valve weld or seam **94** as shown in **FIG. 2**. Preferably the electromagnetic energy which is applied for the bonding comprises a laser beam, an infrared beam, or an ultrasonic beam having a wavelength suitable for polymer joining, e.g., polymer laser welding, infrared welding, or ultrasonic welding. The welding can be accomplished using an overlap technique wherein the pump interface layer **60** upon which the electromagnetic beam is first incident, permits transmission of the electromagnetic beam. After passing through pump interface layer **60**, the electromagnetic beam is incident upon subassembly cover layer **70**. The subassembly cover layer **70** is comprised of a dark, energy-absorbing material which is optically close to the wavelength of the electromagnetic energy used for the bonding. A bond or weld seam occurs where the electromagnetic is absorbed. Thus, inlet valve weld or seam **92** and electromagnetic outlet valve weld or seam **94** depict the positions where the electromagnetic weld is formed for securing subassembly cover layer **70** to pump interface layer **60**, with intermediate layer **80** being embedded therebetween.

[**0043**] As mentioned above, the third step of forming valve subassembly **50** comprises sealing the periphery of subassembly cover layer **70** to pump interface layer **60**, thereby encasing intermediate layer **80** between subassembly cover layer **70** and pump interface layer **60** so that fluid will not intrude to reach intermediate layer **80**. This third step can be accomplished by electromagnetic welding in similar manner as the second step, but with the electromagnetic beam positioned and directed to travel proximate but just inside the periphery of subassembly cover layer **70**, and thereby trace the cover weld or seam **100** shown in **FIG. 3**. The step of bonding periphery of subassembly cover layer **70** to pump interface layer **60** can occur simultaneously with the preceding step of bonding the flaps.

[**0044**] In the electromagnetic welding mode, at least one of the interface layer **60** and the cover layer **80** (preferably the interface layer **60**) is formed from an electromagnetically transmissive material. For the valve subassembly embodiments described that involve electromagnetic bonding, preferably the electromagnetically transmissive material is a thermal polymer, a thermo-plastic elastomer, a thermoplast, or a combination thereof.

[**0045**] Other aspects of electromagnetic bonding operations for a valve subassembly as well as for a pump are described in simultaneously-filed United States Patent Application Serial Number (Attorney Docket 4209-54), entitled ELECTROMAGNETICALLY BONDED PUMPS AND PUMP SUBASSEMBLIES AND METHODS OF FABRICATION, which is incorporated by reference herein in its entirety.

[**0046**] In another mode, the bonding of the second step and the third steps can be achieved using adhesive bonding. An adhesive can be applied at locations comparable to the welds or seams mentioned above. Suitable adhesives for such bonding can include, for example, epoxies and ultraviolet (UV) curable adhesives.

[**0047**] A valve subassembly **50** such as that described above has particular but not necessarily unique utility in a fluidic pump. As an example, valve subassembly **50** can be included in a pump **20** which is illustrated in exploded manner in **FIG. 3**. As assembled, the pump **20** of **FIG. 3** is also seen from the top in **FIG. 4** and from the bottom in **FIG. 5**. The pump **20** has a base plate or pump base member **22** and a diaphragm layer **24**. The pump base member **22** has a pump chamber surface **44** (see **FIG. 4**) and a valve interface surface **46** (see **FIG. 3** and **FIG. 5**). An inlet port **36** and an outlet port **38** are provided in the pump base member. Piezoelectric diaphragm layer **24** is secured (e.g., by electromagnetically welded) to the pump chamber surface **44** for defining pumping chamber **26** between the pump base member **22** and diaphragm layer **24**. Diaphragm layer **24** of pump **20** comprises a piezoelectric central region **30** selectively deformable upon application of an electrical signal for pumping fluid into and out of the pumping chamber. If desired (as in the case of fabrication by electromagnetic bonding), an electromagnetically transmissive region **32** can surround the central piezoelectric region **30**. A bond (such as an electromagnetic weld) illustrated by seam **34**, bonds the region **32** of the diaphragm layer **24** to the base member **22**.

[**0048**] Valve subassembly **50** is bonded or attached to valve interface surface **44** of the pump base member **22** for providing (as shown in **FIG. 5**) the inlet valve **52** which selectively opens and closes the inlet port **36** and the outlet valve **54** which selectively opens and closes the outlet port **38**. As shown in **FIG. 5**, inlet valve **52** may have a dimple **99** formed on an underside surface. In similar fashion, outlet valve **54** may have a dimple formed on an upper surface thereof in alignment with outlet port **38** (see **FIG. 3**).

[**0049**] Preferably the valve subassembly **50** has a footprint which is substantially the same as the pump, e.g., of pump base plate/member **22**. For example, in one example implementation, preferably but not necessarily, pump interface layer **60** is planar and coextensive in size with pump base member **22**, and has fastening apertures **96** which are aligned with fastening apertures **40** of pump base member **22**.

[**0050**] Although various embodiments have been shown and described in detail, the claims are not limited to any particular embodiment or example. None of the above description should be read as implying that any particular element, step, range, or function is essential such that it must be included in the claims scope. The scope of patented subject matter is defined only by the claims. The extent of legal protection is defined by the words recited in the allowed claims and their equivalents. It is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements.

What is claimed is:

1. A multilayer valve subassembly comprising:

an interface layer having an interface layer flap;

a cover layer having a cover layer flap;

an intermediate layer positioned between the interface layer and the cover layer, the intermediate layer having an intermediate layer flap essentially aligned with the interface layer flap and the cover layer flap;

a first bond for adhering the cover layer to the interface layer;

a flap bond for sealing the interface layer flap between the cover layer flap and the interface layer flap and thereby forming a multilayer valve flap.

2. The apparatus of claim 1, wherein the each of the interface layer flap, the cover layer flap, and the interface layer flap has a substantially U-shape.

3. The apparatus of claim 1, wherein at least one of the first bond and the second bond is an electromagnetic bond formed by absorption of electromagnetic energy.

4. The apparatus of claim 1, wherein the interface layer is not in contact with the first bond or the second bond and has a size that permits the interface layer to float in a pocket formed between the interface layer and the cover layer.

5. The apparatus of claim 1, wherein the intermediate layer serves as a stabilizing or stiffener layer.

6. The apparatus of claim 1, wherein the intermediate layer comprises an electroconductive metal.

7. The apparatus of claim 1, wherein the cover layer comprises an elastomer.

8. The apparatus of claim 1, wherein the interface layer has an interface layer first flap and an interface layer second flap; wherein the intermediate layer has an intermediate layer first flap and an intermediate layer second flap; wherein the cover layer has a cover layer first flap and a cover layer second flap; and further comprising:

a first flap bond for bonding the first flap of the interface layer to the first flap of the cover layer whereby the first flap of the intermediate layer sandwiched between the first flap of the interface layer and the first flap of the cover layer forms a first valve flap;

a second flap bond for bonding the second flap of the interface layer to the second flap of the cover layer whereby the second flap of the intermediate layer sandwiched between the second flap of the interface layer and the second flap of the cover layer forms a second valve flap.

9. The apparatus of claim 8, wherein the intermediate layer first flap and the intermediate layer second flap are electrically isolated.

10. The apparatus of claim 8, wherein the first valve flap is centrally formed with respect to the interface layer, the intermediate layer, and the cover layer.

11. The apparatus of claim 1, wherein a multilayer structure formed by the bonding of the cover layer to the interface layer has a footprint which is substantially equal to a pump footprint.

12. The apparatus of claim 1, wherein a multilayer structure formed by the bonding of the cover layer to the interface layer has an essentially circular shape.

13. A method of fabricating a valve subassembly comprising:

forming flaps in each of an interface layer, an intermediate layer, and a cover layer;

positioning the intermediate layer between the interface layer and the cover layer;

bonding the flap of the interface layer to the flap of the cover layer whereby a valve flap is formed, the valve flap being comprised of the flap of the intermediate layer sandwiched and sealed between the flap of the interface layer and the flap of the cover layer.

14. The method of claim 13, further comprising:

forming at least one of the interface layer and the cover layer from an electromagnetically transmissive material;

electromagnetically welding the flap of the interface layer to the flap of the cover layer.

15. The method of claim 13, wherein the shape of the valve flap is essentially U shaped.

16. The method of claim 13, further comprising forming the intermediate layer from an electroconductive metal

17. The method of claim 13, further comprising forming the cover layer from an elastomer.

18. The method of claim 13, further comprising:

forming two flaps in each of the interface layer, the intermediate layer, and the cover layer, whereby the interface layer has an interface layer first flap and an interface layer second flap; wherein the intermediate layer has an intermediate layer first flap and an intermediate layer second flap; wherein the cover layer has a cover layer first flap and a cover layer second flap;

bonding the first flap of the interface layer to the first flap of the cover layer for forming a first valve flap, the first valve flap comprising the first flap of the intermediate layer sandwiched between the first flap of the interface layer and the first flap of the cover layer;

bonding the second flap of the interface layer to the second flap of the cover layer for forming a second valve flap, the second valve flap comprising the second flap of the intermediate layer sandwiched between the second flap of the interface layer and the second flap of the cover layer.

19. The method of claim 18, further comprising electrically isolating the intermediate layer first flap and the intermediate layer second flap.

20. The method of claim 18, further comprising centrally forming the first valve flap with respect to the interface layer, the intermediate layer, and the cover layer.

21. The method of claim 13, further comprising forming a multilayer structure by bonding of the cover layer to the interface layer to have a footprint which is substantially equal to a pump footprint.

22. A pump comprising:

a pump base member having a first surface and a second surface and at least one port;

a diaphragm covering at least a portion of the first surface of the pump base member and defining a pumping chamber between the pump base member and the diaphragm layer;

a multilayer valve subassembly positioned on the second surface of the pump base member for selectively communicating fluid through the port, the multilayer valve subassembly comprising:

an interface layer having an interface layer flap;

a cover layer having a cover layer flap;

an intermediate layer positioned between the interface layer and the cover layer, the intermediate layer having an intermediate layer flap essentially aligned with the interface layer flap and the cover layer flap;

a first bond for adhering the cover layer to the interface layer;

a flap bond for sealing the interface layer flap between the cover layer flap and the interface layer flap and thereby forming a multilayer valve flap.

23. The apparatus of claim 22, wherein the each of the interface layer flap, the cover layer flap, and the interface layer flap has a substantially U-shape.

24. The apparatus of claim 22, wherein at least one of the first bond and the second bond is an electromagnetic bond formed by absorption of electromagnetic energy.

25. The apparatus of claim 22, wherein the interface layer is not in contact with the first bond or the second bond and has a size that permits the interface layer to float in a pocket formed between the interface layer and the cover layer.

26. The apparatus of claim 22, wherein the intermediate layer serves as a stabilizing or stiffener layer.

27. The apparatus of claim 22, wherein the intermediate layer comprises an electroconductive metal.

28. The apparatus of claim 22, wherein the cover layer comprises an elastomer.

29. The apparatus of claim 22, wherein the interface layer has an interface layer first flap and an interface layer second flap; wherein the intermediate layer has an intermediate layer first flap and an intermediate layer second flap; wherein the cover layer has a cover layer first flap and a cover layer second flap; and further comprising:

a first flap bond for bonding the first flap of the interface layer to the first flap of the cover layer whereby the first flap of the intermediate layer sandwiched between the first flap of the interface layer and the first flap of the cover layer forms a first valve flap;

a second flap bond for bonding the second flap of the interface layer to the second flap of the cover layer whereby the second flap of the intermediate layer sandwiched between the second flap of the interface layer and the second flap of the cover layer forms a second valve flap.

30. The apparatus of claim 29, wherein the intermediate layer first flap and the intermediate layer second flap are electrically isolated.

31. The apparatus of claim 29, wherein the first valve flap is centrally formed with respect to the interface layer, the intermediate layer, and the cover layer.

32. The apparatus of claim 22, wherein a multilayer structure formed by the bonding of the cover layer to the interface layer has a footprint which is substantially equal to a footprint of the pump base member.

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