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.
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 myriad 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, 2005, entitled “PIEZOELCTRIC 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.

[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 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, turbines 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 subjected responding in the course of valve operation to stimuli for opening or closing the valves, such as fluidic pressure or even electrical signals. 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 forms 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 801 and intermediate layer segment 800. The intermediate layer segment 801 bears intermediate layer inlet flap 82, the intermediate layer segment 800 bears intermediate layer outlet flap 84. A tab 801T is provided at a circumference portion of intermediate layer segment 801, and similarly a tab 800T is provided at a circumference portion of intermediate layer segment 800. The tabs 801T and 800T 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 intermediate layer inlet flaps 62, 64; the respective intermediate 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, 64, 72 and 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 intermediate 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.

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.

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 that involve electromagnetic bonding, preferably the electromagnetically transmissive material is a thermal polymer, a thermo-plastic elastomer, a thermoplastic, or a combination thereof.

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.

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.

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.

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).

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.

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-shaped.
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 stiffening 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.

* * * * *