

EXTENDED SENSOR BACK VOLUME

BACKGROUND OF THE INVENTION

5 [0001] A capacitive microphone typically includes a diaphragm having an electrode attached to a flexible member and a backplate parallel to the flexible member attached to another electrode. The backplate is relatively rigid and typically includes a plurality of holes to allow air to move between the backplate and the flexible member. The backplate and flexible member form the parallel plates of a capacitor. Acoustic pressure on the diaphragm causes it to deflect, thereby changing the capacitance of the capacitor. The change in
10 capacitance is processed by electronic circuitry to provide an electrical signal that corresponds to the change.

[0002] Similar kinds of sensors may be used for measuring pressure in other than acoustic applications.

15 [0003] Microelectromechanical system (MEMS) devices, including miniature microphones and other kinds of pressure sensors, are fabricated with techniques commonly used for making microelectronics such as integrated circuits. Potential uses for MEMS sensors include microphones for hearing aids and mobile telephones, and pressure sensors for vehicles.

BRIEF SUMMARY OF THE INVENTION

20 [0004] A microelectromechanical system (MEMS) transducer comprises a diaphragm and a back plate. The diaphragm and back plate are spaced apart and are made of semiconductor material using microelectronic fabrication techniques. The transducer also includes a pedestal comprising a cavity. The pedestal has a first end and a second end, and the back
25 plate of the transducer is affixed to the first end, substantially covering the cavity. An extension member is affixed to the second end of the pedestal, contributing to an enlarged back volume for the transducer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] A more detailed description of the invention will now be provided by way of example only with reference to the accompanying drawing. It should be appreciated, however, that the drawings should not be construed as limiting on the invention in any way.

5 **[0006]** Figures 1A-1C illustrate top perspective, bottom perspective, and cross-section views of a MEMS transducer.

[0007] Figure 1D shows the MEMS transducer of Figures 1A-1C attached to a substrate.

[0008] Figure 2 is a side view of a first wafer and a second wafer to be used to fabricate a MEMS transducer, in accordance with an example embodiment of the invention.

10 **[0009]** Figure 3 illustrates a cross-sectional side view of the first wafer following patterning and etching of a cavity, in accordance with an example embodiment of the invention.

[0010] Figure 4 illustrates a cross-sectional side view of the first wafer and the second wafer bonded together, in accordance with an example embodiment of the invention.

15 **[0011]** Figure 5 illustrates a cross-sectional side view of the bonded wafers following patterning and etching of holes in the second wafer, in accordance with an example embodiment of the invention.

[0012] Figure 6 illustrates the attachment of a glass pedestal to the bonded wafers, in accordance with an example embodiment of the invention.

20 **[0013]** Figure 7 illustrates a cross sectional view of the bonded wafers following patterning and etching of a cavity and bond areas, in accordance with an example embodiment of the invention.

[0014] Figure 8 illustrates a cross sectional view of the bonded wafers after a grinding operation, in accordance with an example embodiment of the invention.

25 **[0015]** Figure 9 illustrates the deposition of metal onto the bonding areas, in accordance with an example embodiment of the invention.

[0016] Figure 10 illustrates the bonding of an extension member to the assembly of Figure 9, in accordance with an example embodiment of the invention.

[0017] Figure 11 illustrates a step in the fabrication of an extension member, in accordance with an example embodiment of the invention.

[0018] Figure 12 illustrates another step in the fabrication of the example extension member.

[0019] Figure 13 illustrates another step in the fabrication of the example extension member.

5 **[0020]** Figure 14 illustrates another step in the fabrication of the example extension member.

[0021] Figure 15 illustrates another step in the fabrication of the example extension member.

10 **[0022]** Figure 16 illustrates another step in the fabrication of the example extension member.

[0023] Figure 17 illustrates another step in the fabrication of the example extension member.

[0024] Figure 18 illustrates another step in the fabrication of the example extension member.

15 **[0025]** Figure 19 illustrates another step in the fabrication of the example extension member.

[0026] Figure 20 illustrates the example extension member in an upright position.

[0027] Figure 21 illustrates the sensor of Figure 10 mounted in a package, in accordance with an example embodiment of the invention.

20 **[0028]** Figure 22 illustrates the sensor of Figure 10 mounted in an alternative package, in accordance with an example embodiment of the invention.

[0029] Figure 23 shows an other alternative arrangement of components, in accordance with another example embodiment of the invention.

25 **[0030]** Figure 24 shows an extension member in accordance with another example embodiment of the invention.

[0031] Figure 25 shows the extension member of Figure 24 attached to a sensor, in accordance with an example embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0032] The sensor and method of fabricating the sensor will be described with reference to one particular embodiment of the sensor. It should be appreciated, as noted above, that this description is not intended to limit the invention. It should also be noted that the drawings
5 illustrated are not drawn to scale and are given for illustrative purposes only. For example, the vertical scale of several of the figures is exaggerated.

[0033] Figures 1A-1C illustrate one embodiment of a MEMS transducer **100**. Figure 1A is a top perspective view, Figure 1B is a bottom perspective view, and Figure 1C shows transducer **100** in cross section. Diaphragm **101** and backplate **102** are fabricated using
10 integrated circuit manufacturing techniques, and form the two plates of a parallel plate capacitor, with air gap **103** between them. The layers forming diaphragm **101** and backplate **102** are made of semiconductor material such as silicon. Bond pads **104**, formed in the semiconductor material, provide connection points for electrically connecting the two
15 capacitor plates to other components, for example by wire bonding, flip chip mounting, bump bonding, or other means. In transducer **100**, the semiconductor layers are bonded to pedestal **105**, which may be made of glass. Pedestal **105** includes a hole **106** approximately the diameter of diaphragm **101**. Hole **106** provides a back volume for the transducer.

[0034] Transducer **100** may be mounted to a substrate in the fabrication of a packaged product, as is shown in Figure 1D. In Figure 1D, adhesive **107** is placed between pedestal
20 **105** and substrate **108**. The size of the transducer back volume **110** is determined primarily by the depth and size of hole **106**, but may also be affected by the thickness of adhesive layer **107**. The size of the back volume **110** may affect the performance of a sensor such as transducer **100**. For example, if transducer **100** is used as a microphone, a larger back
25 volume may reduce the apparent stiffness of the air inside the back volume, and allow a higher sensitivity or signal-to-noise ratio for the microphone. This may be the result of the behavior of air residing between the diaphragm **101** and backplate **102**. In general, as the diaphragm responds to sound, it squeezes and pushes air through the holes in backplate **102**. Increased resistance to flow of air through the holes may provide increased damping to the diaphragm, with a corresponding reduction in sensitivity. In some applications, the back
30 volume size may have other effects, for example affecting the frequency response of a pressure sensor.

[0035] Figures 2-9 illustrate the fabrication of an example MEMS sensor similar to transducer 100.

[0036] Figure 2 is a side view of a first wafer 201 and a second wafer 202 to be used to fabricate a sensor. The first wafer 201 includes a first layer 203 of highly doped silicon, a second layer 204 of silicon substrate and an intermediate oxide layer 205. The first layer 203 may include p^{++} doped silicon and the second layer 204 may include an n-type substrate. Alternatively, the first layer 203 may include an n^{++} doped silicon and the second layer 204 may include a p-type substrate.

[0037] Typically, the first layer 203 is of the order of 4 microns thick and the oxide layer 205 is of the order of 2 microns thick. The thickness of these layers will generally depend on the characteristics required for the sensor. The second layer 204 may be larger than the first layer 203 and the oxide layer 205. For example, the second layer 204 may be in the order of 400 to 600 microns thick.

[0038] In this example embodiment, the second wafer 202 is formed from silicon. Other semiconductor materials may be used. The second wafer 202 is heavily doped and may be either p-type or n-type silicon. In other embodiments, different silicon surfaces or structures may be used.

[0039] It will be appreciated that the first wafer 201 includes a first major surface 206 formed from the heavily doped silicon of the first layer 203 and a second major surface 207. Likewise, the second wafer 202 includes a first major surface 208 and a second major surface 209. Oxide layers 210 have been formed on major surfaces 206, 207, 208, and 209.

[0040] Oxide layers 210 are may be formed on the major surfaces 206-209 of the wafers 201 and 202 through thermal growth or a deposition process. Forming oxide layers 210 on both major surfaces 206-207 and 208-209 wafers 201 and 202 respectively reduces the risk of distorting the wafers that may occur if oxide were only formed on one major surface on each wafer. That being said, in an alternative embodiment to that illustrated in Figure 2, an oxide layer 210 may be only formed on the first major surface 206 of the first wafer 201 and the first major surface 208 of the second wafer 202. The thickness of the oxide layers 210 may be less than the thickness of the first and second wafers 201 and 202.

[0041] In fabricating the sensor, the first wafer 201 and the second wafer 202 are initially processed separately before being bonded together and further processed. It will also be

appreciated that while the figures and the following discussion describe the fabrication of a single sensor, in actual practice many sensors may be produced by the processing of wafers containing multiple sensor substrates, and the sensors separated after fabrication in a process known as singulation or dicing.

5 **[0042]** Figure 3 illustrates the first wafer **201** in which a cavity **301** has been patterned and etched. In particular, the cavity **301** has been patterned and etched through the oxide layer **210** on the first major surface **206** of the first layer **203** of the first wafer **201**, and into the first layer **203** of the first wafer **201**. In this step, a portion of the heavily doped silicon forming the first layer **203** is etched away to produce a thin section **302** of the heavily doped silicon of the first layer **203**.
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[0043] The thickness of the thin section **302** will determine the properties of the sensor eventually fabricated as this thin section **302** of highly doped silicon will form the flexible member of the diaphragm of the sensor, as illustrated in the following drawings.

[0044] A wet or dry silicon etch may be employed in this step. In one embodiment a reactive ion etch (RIE) is used to form the cavity **301**. Generally, the etch is a time etch. Therefore, the final thickness of the thin section **302**, and consequently the flexible member of the diaphragm, is dependent on the etching time. Further, the desired shape of the cavity **301** will generally be dictated by the desired properties of the sensor.
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[0045] Figure 4 shows the first and second wafers **201** and **202** bonded together. The major surfaces bonded together, via respective oxide layers **210**, are the first major surface **206** of the first wafer **201** and the first major surface **208** of the second wafer **202**. In one embodiment the wafers **201** and **202** are bonded together through their respective oxide layers **210** using fusion bonding.
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[0046] In bonding the wafers **201** and **202** together, an air gap **401** is formed between the wafers **201** and **202** corresponding with the cavity **301** formed in a previous etching step.
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[0047] As is shown in Figure 5, a plurality of holes **501** are then patterned and etched into the highly doped silicon of the second wafer **202** in a region associated with the air gap **401** and, therefore, the thin section **302**. When the holes **501** are formed, a global etch is conducted such that the holes **501** extend through to the air gap **401**. In effect, holes **501** are formed that extend through the second wafer **202** to the air gap **401**. Holes **501** may be
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formed by deep reactive ion etching (DRIE). At this or another convenient time, a vent hole 502 may be formed through wafer 202 and first layer 203 of wafer 201.

[0048] Figure 6 illustrates the attachment of a pedestal 601 to the bonded wafers. Pedestal 601 is preferably made of glass, for example Pyrex, and is preferably attached to wafer 202 by anodic bonding or another form of wafer bonding. Other materials and attachment methods are also possible. For example, pedestal 601 may be made of silicon or another semiconductor material. Pedestal 601 may be attached to the bonded wafers by fusion bonding, with an adhesive, or by other means. Pedestal 601 has a first end and a second end. Back plate 604 of the transducer is affixed to the first end of pedestal 601. In Figure 6, this is the bottom of pedestal 601, although one of skill in the art may recognize that a finished transducer may be used in any orientation, and the first end of pedestal 601 may not always be the bottom end. Pedestal 601 may be previously prepared to include a cavity 602 that generally corresponds to the lateral dimensions of cavity 401. Alternatively, pedestal 601 may be formed by bonding a solid wafer to silicon wafer 202, and then etching cavity 602 from the glass wafer. For example, a masking layer of chrome and gold may be deposited onto the glass wafer and the cavity 602 may be formed by wet or dry etching, for example using HF. Preferably, the height of pedestal 601 is many times the combined remaining thickness wafers 201 and 202. For example, pedestal 601 may be up to several millimeters in height.

[0049] As is shown in Figure 7, another DRIE etch process is performed to remove parts of first wafer 201, forming cavity 701 and bonding pad locations 702 and 703. As is evident in Figure 7, bonding pad location 702 is an exposed surface of layer 203 of first wafer 201, from which diaphragm 705 is formed. Bonding pad location 703 is an exposed surface of second wafer 202, from which forms the backplate 604 of the MEMS microphone. After cavity 701 is formed, vent hole 502 passes completely through wafer 202 and layer 203 of wafer 201 to cavity 701. Vent hole 502 may be formed adjacent back plate 604 and diaphragm 705 as shown, or may include a passage through diaphragm 705.

[0050] The remaining portion of layer 204 of first wafer 201 is then thinned in a grinding operation. The result of this operation is shown in Figure 8. Note that in Figure 8 and the following figures, the assembly is inverted as compared with the previous figures.

[0051] Figure 9 illustrates the deposition of metal onto bonding areas 702 and 703. For example, aluminum pads 901 and 902 may be formed on bonding areas 702 and 703

respectively by vapor deposition. Prior to vapor deposition, a shadow mask **903** may be placed over the wafers to ensure that only bonding areas **702** and **703** receive deposited metal. The shadow mask is removed after the metal deposition is complete. Pads **901** and **902** allow electrical connections to be made to the two plates of the capacitor formed by diaphragm **705** and backplate **604**. For example, pads **901** and **902** may be independently connected by wire bonds to a substrate on which the sensor is eventually mounted.

[0052] In some cases, it is desirable to make the lateral dimensions of the sensor as small as possible, so as to produce as many sensors as possible from a semiconductor wafer.

However, as the size of the sensor is reduced, the size of the back volume is also reduced, and the performance of the sensor may be compromised. In example embodiments, a sensor as shown in Figure 9 may have a square footprint of 1.2mm by 1.2mm, or a square footprint of 1.7mm by 1.7 mm, or another shape or size. For example, the sensor need not be square, but could be rectangular, circular, or have another foot print shape. Similarly, the sensor may have one or more lateral dimensions less than 1.2mm, larger than 1.7mm, up to a dimension of several millimeters, or any size between.

[0053] Figure 10 illustrates an apparatus and method for extending or enlarging the back volume of a sensor, in accordance with an example embodiment of the invention. In this example, an extension member **1001** is affixed to the bottom of pedestal **601**. Extension member **1001** may be made, for example of a semiconductor material such as silicon, germanium, or another semiconductor material. Alternatively, extension member **1001** may be made of glass, or any other suitable material. Preferably, extension member **1001** is made of a material that can withstand the temperatures used in packaging a semiconductor product, which may reach 260 °C or more. In the example of Figure 10, extension member **1001** may be affixed to pedestal **601** or another part of the sensor by an adhesive, for example room temperature vulcanizing (RTV) silicone adhesive, or another compliant or substantially rigid adhesive. Alternatively, extension member **1001** may be attached to the sensor or pedestal by fusion bonding, by anodic bonding, by eutectic bonding, or by another means. The result is completed transducer **1000**.

[0054] Figures 11-20 illustrate the fabrication of an extension member, in accordance with an example embodiment of the invention. Preferably, the extension member is made from a material that is not electrically conductive, or from a semiconductor material using semiconductor circuit fabrication processes. Each of Figures 11-14 shows a cross-section

view of a wafer segment at various stages in the fabrication of the extension member, and also shows a perspective view of the wafer segment. Each of Figures 15-20 shows a cross-section view, and also both upper and lower perspective views of the wafer at the corresponding fabrication stage.

5 **[0055]** In Figure 11, a wafer **1100** includes oxide layers **1101** on its upper and lower surfaces. The oxide layer may be, for example, on the order of 0.5 to 1.0 micrometer in thickness, although other thicknesses are possible. In one example embodiment, wafer **1100** may be, for example about 250 to 600 micrometers in thickness. Other thicknesses less than 250 microns or greater than 600 microns are also possible. In Figure 12, a resist coat **1201**
10 has been applied to the upper surface of wafer **1100**.

[0056] In Figure 13, the resist coat **1201** has been patterned and baked, outlining a rectangular area **1301** on the upper surface of wafer **1100**. In Figure 14, a resist coat **1401** has been applied to the lower surface of wafer **1100**. In Figure 15, resist coat **1401** has been patterned and baked, outlining a generally circular area **1501** on the lower surface of wafer
15 **1100**. While areas **1301** and **1501** are shown as rectangular and circular respectively, either or both may be rectangular, circular, oval, polygonal, or have any other suitable shape.

[0057] In Figure 16, both sides of wafer **1100** have been etched to remove the portions of oxide layers **1101** not protected by resist coat layers **1201** and **1401**. In Figure 17, a cavity **1701** has been created in the upper surface of wafer **1100**, outlined by resist coat **1201**.
20 Cavity **1701** may be formed, for example, by deep reactive ion etching (DRIE).

[0058] In Figure 18, the lower surface of wafer **1100** has been similarly etched to form hole **1801**, outlined by resist coat **1401**. In Figure 19, the resist and oxide layers have been stripped off, leaving completed extension member **1001**. In Figure 20, extension member **1001** has been inverted into its usual orientation. Of course, extension member **1001** and any
25 sensor it is comprised in may be used in any orientation.

[0059] While extension member **1001** is shown as being generally square with a rectangular chamber and a generally circular opening for interfacing with the transducer back hole, one of skill in the art will recognize that many other shapes are possible. For example, the chamber may have a cross-sectional shape that is rectangular, polygonal, round, oval,
30 elliptical, bounded by some other curve, or of another shape. Similarly, the opening for interfacing with the sensor chip may also be square, rectangular, polygonal, oval, elliptical, or

have some other shape. Neither the opening nor the chamber need have a constant cross section. For example, the chamber may have angled walls that include draft.

[0060] In Figure 20, dimension “a” indicates the size of the opening that interfaces with the transducer back hole. The size of the opening may be chosen to achieve particular sensor performance parameters. Rather than one opening, a plurality of smaller openings may be provided, and the plurality of smaller openings may be fabricated by steps essentially the same as those described for fabricating extension member **1001**.

[0061] Figure 21 shows the transducer **1000** of the previous figures mounted in an example package **2100**. Package **2100** comprises a substrate **2101**, which may be for example a printed circuit board, a ceramic substrate, a semiconductor substrate, a flexible circuit, or another kind of substrate. Transducer **1000** is may be attached to substrate **2101** using an adhesive layer **2102**. The adhesive used may be, for example, a room temperature vulcanization (RTV) silicone adhesive available from the General Electric Company of Fairfield, Connecticut, USA. Many other attachment methods are possible, including any suitable method used for attaching semiconductor chips to substrates. In the example arrangement of Figure 21, back volume **2108** is enlarged, as compared with a system in which pedestal **601** is affixed to substrate **2101** directly without the benefit of extension member **1001**. This extended back volume **2108** may provide enhanced performance of transducer **1000**, and may allow the optimization of various performance parameters by selection of the dimensions of extension member **1001**, in conjunction with the design of other parts of the transducer. In the example package of Figure 21, transducer **1000** is electrically connected to substrate **2101** by wire bonds **2103** and **2104**. One or more additional electronic components **2105** may also be attached and electrically connected to substrate **2101**. A cover **2106** may be placed over transducer **1000** and attached to substrate **2101**. In this example, cover **2106** comprises an aperture **2107** through which sound may enter and reach transducer **1000**. Cover **2106** may be made, for example, of a metal such as stamped sheet steel or copper, and may be plated. Cover **2106** may also be made of a polymer, and may be covered with a conductive layer. Cover **2106** provides protection for transducer **1000**, and may be electrically connected to traces on substrate **2101**, for example to provide protection from electromagnetic interferences or other interference signals. Many other package configurations are possible.

[0062] In Figure 21, extension member **1001** has the same footprint as pedestal **601** and the rest of transducer **1000**. In this embodiment, wafers comprising an array of sensor diaphragms and backplates may be fabricated and then laminated with an array of pedestals and another wafer having an array of extension members formed in it. The individual sensors
5 may then be separated by dicing or singulation. Other assembly methods may be used.

[0063] Figure 22 shows transducer **1000** mounted in an alternative package **2200**. Package **2200** is a “reverse mount” package having substrate **2201** that includes an aperture **2202** through which sound may enter and reach transducer **1000**. In this example, cover **2203** does not include an aperture. Cover **2203** may be made of materials like those of which cover
10 **1106** may be made, and may be electrically connected to circuitry on substrate **2201**. In some embodiments, a package may be provided with apertures in both a cover and a substrate.

[0064] While Figures 21 and 22 show transducer **1000**, including an extension member **2204**, mounted to a substrate, other applications are also possible. For example, a transducer such as example transducer **1000** may be mounted in a pre-molded cavity package, attached
15 to a silicon submount, or mounted on top of an integrated circuit. The attachment may be die-to-die. And while Figures 21 and 22 show electrical connections made from transducer **1000** by wire bonds such as bonds **2103** and **2104**, other attachment methods may be used. For example, a transducer according to an embodiment of the invention may be flip-chip mounted or bump bonded to another component, and such a mounting may make electrical
20 connections, may affix the transducer mechanically to the other component, or both. In some embodiments, metallic bumps made of gold or another metal may be used for bump-bonding the transducer to another component.

[0065] In Figure 22, extension member **2204** does not have the same footprint as pedestal **601** and the rest of transducer **1000**. In this case, extension member **2204** may be assembled
25 to transducer **1000** during packaging of the transducer, and not before transducer **1000** is singulated from an array of similar devices.

[0066] Figure 23 shows another alternative arrangement of components, in accordance with another example embodiment of the invention. In Figure 23, an encapsulation layer **2301** has been affixed to transducer **1000** before transducer **1000** is mounted onto substrate **2302**.

30 Encapsulation layer **2301** may be made, for example, of silicon or another semiconductor material, or another suitable material.

[0067] Figure 24 shows another extension member **2401**, in accordance with another example embodiment of the invention. Extension member **2401** is fabricated in a way similar to extension member **1001**, except that no opening is provided through the member **2401**.

Extension member **2401** may be used as shown in the example embodiment of Figure 25. In

5 Figure 25, extension member **2401** is bonded to one side of pedestal **601**, using a bonding material **2501**. For example, bonding material **2501** may be an RTV adhesive or another kind of pliable adhesive, a substantially rigid adhesive **2506**, or any other suitable bonding material. Pedestal **601** and extension member **2401** are bonded to a substrate **2502** using any suitable kind of die attach material or other adhesive, but leaving a center channel **2503**
10 unbonded so that back chamber **2504** includes both the back hole of the transducer and the chamber provided by extension member **2401**.

[0068] A transducer according to an embodiment of the invention may be used in low-pressure applications, for example as a microphone that responds to pressure fluctuations of an acoustic signal, or may be used in higher pressure applications. For example, a transducer

15 according to a embodiment of the invention may be used to measure the pressure of various gasses or liquids in a motor vehicle engine. Various fabrication parameters may be adjusted depending on the intended application of a sensor. For example, a microphone transducer may have a thin, flexible diaphragm, while a sensor designed for higher pressure applications may be fabricated with a comparatively thicker, stiffer diaphragm. For the purposes of this
20 disclosure, an acoustic signal may be but is not limited to a signal audible to humans. An acoustic signal may be a signal having an amplitude below the threshold of human hearing, or an amplitude above a level that may cause damage to a human ear. An acoustic signal may include or be composed entirely of one or more frequency components outside the range of human delectability. For example, an acoustic signal may have a frequency or frequencies
25 below 20 Hertz, or may have a frequency or frequencies above 20 kHz. A signal in this upper frequency range is sometimes referred to as a ultrasonic signal.

[0069] One of skill in the art will also recognize the order of operations may be varied from the order described above. For example, hole **1801** may be deep etched before cavity **1701**.

[0070] While the above examples are shown in the context of a capacitive sensor, an
30 extension member in accordance with an embodiment of the invention may be used with other kinds of sensors as well. For example, a piezoresistive or piezoelectric sensor may comprise a diaphragm and use a back volume, but lack the back plate shown in the Figures.

Even so, the shape and size of the back volume may affect the performance of a piezoresistive or piezoelectric sensor, and an extension member similar to member **1001** may be used to enhance the performance of such a sensor.

[0071] The sensor and arrangements embodying the invention may provide a number of advantages. The sensor allows for an arrangement having a large and well controlled back volume. The shape and size of the back volume may be adjusted by the selection of the thicknesses of pedestal **601** and wafer **1100** and the shape and size of cavity **1701** and hole **1801**. Especially with regard to acoustic applications, back volume is important to the acoustic performance of a device as it affects sensitivity and frequency response. In some embodiments, a microphone with an extension member may have a sensitivity approximately 2 dB higher than the sensitivity of a similar microphone not having an extension member.

[0072] The foregoing describes the invention including preferred forms thereof. Alterations and modifications as will be obvious to those of skill in the art are intended to be incorporated in the scope hereof as defined by the accompanying claims.

WHAT IS CLAIMED IS:

- 1 1. A microelectromechanical system (MEMS) transducer, comprising:
2 a diaphragm and a back plate, the diaphragm and back plate spaced apart and
3 made of semiconductor material using microelectronic fabrication techniques;
4 a pedestal comprising a cavity, the pedestal having a first end and a second
5 end, the back plate of the transducer affixed to the first end and substantially covering the
6 cavity;
7 an extension member affixed to the second end of the pedestal, the extension
8 member contributing to an enlarged back volume for the transducer.