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Capacitive vacuum measuring cell

The present invention relates to a capacitive vacuum measuring cell according to the generic term of patent
5 claim 1.

It is known that pressures or pressure differences can be measured by applying pressure to a thin membrane and measuring its deflection. A known and suitable method for measuring the deflection is to design the membrane
10 arrangement as a variable electrical capacitance where the capacitance change which correlates with the pressure change is evaluated by measurement electronics in the known manner. The capacitance is created by arranging a thin, flexible membrane very close to another surface and
15 by depositing an electrically conductive film on both mutually opposed surfaces or by fabricating them from electrically conductive material. When pressure is applied to the membrane the deflection changes the distance between the two electrodes which leads to an
20 analyzable capacitance change of the arrangement. Sensors of this type are mass-produced from silicon. The flat basic body as well as the membrane often consist entirely of silicon. There are also versions that are made of composite materials such as silicon with a glass
25 substrate. Such sensors can be produced very economically. However, in vacuum applications pressure sensors of this type are normally usable only for higher pressures in the range of approx. 10^{-1} mbar to several bar. High resolution at pressures below 10^{-1} mbar is no
30 longer achievable with silicon. One of the reasons for this is that the silicon surface reacts with the environment which impairs the sensitive sensor characteristic. Already water vapor that forms part of normal atmospheric air leads to a corresponding reaction
35 on the surfaces. The problem becomes even more serious when the sensor is used in chemically aggressive atmospheres. For this reason attempts were made to

protect such silicon sensors against external influences by passivating the surfaces. Attempts were also made to deposit protective coatings on the surfaces in order to improve the durability and the resistance against
5 chemically aggressive environments as described in DE 41 36 987. Such measures are costly and in the case of mechanically deformable parts such as membranes have only limited success, in particular in highly aggressive media such as fluorine, bromic acid and their compounds which
10 are typically used in vacuum etching processes.

For this reason attempts were made to build vacuum measuring cells entirely from corrosion resistant materials such as Al_2O_3 . A known arrangement of this type is shown in Fig. 1. The vacuum measuring cell consists of
15 a ceramic plate (20) above which a membrane (22) is arranged with a small gap between the two of them and a fusible seal (21) between the ceramic plate (20) and the edge of the membrane. The ceramic plate (20) together with the membrane (22) forms a reference vacuum chamber
20 (25) that is evacuated down during the manufacturing process through a pumping port and which is sealed with a seal (28). The mutually opposed surfaces of the ceramic plate (20) and the membrane (22) inside the reference vacuum chamber (25) are coated with electrically
25 conductive material and connected to insulated external terminals on which the capacitance signal can be evaluated by means of an electronic device (not shown in the illustration). To achieve corrosion resistance plate (20) and membrane (22) are both made of ceramic material
30 such as Al_2O_3 . This vacuum measuring cell in turn is arranged in a vacuum-tight housing (23) that features a port (24) which is connected to the media to be measured. Via port (24) of the vacuum measuring cell the resulting measurement vacuum chamber (26) is sealed off against the
35 membrane (22) by means of an elastomer seal (27) so that the pressures to be measured reach only the surface of the membrane (22). For the purpose of sealing the entire cell is pressed via the ceramic plate (20) and membrane

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(22) against the elastomer seal (27). Up to now vacuum measuring cells of this type have been usable only for higher pressures in the range of 0.1 mbar to 100 bar. In addition this design leads to stress in the materials which at lower pressures, for example < 1 mbar, significantly impairs the reproducibility of measurement results and the resolution. The ceramic membranes (22) used so far have a thickness ranging from 279 μm to 2540 μm . Such designs are not suitable for achieving wide measurement ranges, in particular low pressures of 0.1 mbar to 10^{-6} mbar. In addition designs of this type, as disclosed also in US 5,553,502, are costly.

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The objective of the present invention is to eliminate the disadvantage of the current state of the art. In particular the objective of the present invention is to implement an easy-to-produce, economical vacuum measuring cell that is suitable for measuring pressures from 10^{-6} mbar to 1000 mbar, in particular from 10^{-6} mbar to 1 mbar, with an accuracy of better than 1%, preferably better than 0.3% of the measured value. The measurement range can be covered or subdivided into several vacuum measuring cells or membrane versions according to the invention. In addition this vacuum measuring cell shall be corrosion resistant to aggressive media, have a compact design, and be economical to manufacture.

With respect to the generic vacuum measuring cell the problem is solved through the characteristic features of patent claims 1 and ~~19~~¹⁸. The dependent patent claims relate to preferable other versions of the invention.

The capacitive vacuum measuring cell according to the invention is made entirely out of ceramic, in particular Al_2O_3 . This results in high corrosion resistance and long-term reproducibility. Only in the areas where sealing is required or where feedthroughs are provided are small amounts of materials other than Al_2O_3 used, if the Al_2O_3 is not fused without addition of the foreign material. A vacuum measuring cell consists of a first plate-shaped

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**Insertion on state-of-the-art following first paragraph on
page 3 of description**

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A further measuring cell of the type mentioned is described in WO 95/28624. This measuring cell largely consists entirely of glass ceramic material. The asymmetric construction comprises a first housing body of ceramic and
10 a ceramic membrane spaced from it with a cylindrical glass ring, whereby the membrane and the housing body are connected in sealed form via the glass ring acting as glass alignment, so that a sealed reference pressure chamber is formed. The surfaces of the membrane and housing body are
15 provided at the centre with thin gold layers to form the electrodes and therefore the measuring capacitance, whereby the gold films are significantly smaller than the membrane diameter. Special attention is given to the screens in this design, which cover the entire diameter of the system on
20 both membrane and housing sides, in order to prevent stray capacitance.

In US 5257542 a capacitive vacuum measuring cell is described in which both the housing and membrane are made
25 for example from glass ceramic or plastic. A reference vacuum is provided between the membrane and housing body, which is maintained with the aid of a getter material. The arrangement is mainly employed for the solution of bonding and contact problems in conjunction with electrode
30 contacts. For this purpose at least two separate metallic zones are to be provided, above all within the basic disc, which form series capacitances with respect to the membrane.

35 A capacitive pressure sensor with a membrane and base-plate of plastic, glass or ceramic is described in DE 41 36 995.

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An electrically insulating base-plate and a similarly insulating parallel membrane spaced from the base-plate, mutually connected at the edges and with layer sections forming metallic capacitor electrodes on their opposing internal surfaces, enclose a reference pressure chamber. It is proposed to provide at least two separate base electrodes on the inside of the base-plate to form series connected capacitances with electrically connected counter-electrodes on the membrane, with connections provided on the base-plate.

EP 0 701 112 describes a ceramic cell arrangement for sensor applications, but in particular for piezoelectric, electro-strictive actuators. In this arrangement blister-form ceramic membranes are arranged on a ceramic base body, which are connected to the base body by sintering. This makes it possible to provide several membrane arrangements side-by-side. A method is described of post-forming the blister-form membranes in a partial area of the surface in one process stage, so that the bulges of the membranes are aligned in one plane.

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housing body above which a membrane, sealed along its edges, is arranged so that it encloses a reference vacuum chamber. On the side pointing away from the reference vacuum chamber there is a second housing body, also
5 sealed along its edges, so that a measurement vacuum chamber is formed there. This measurement vacuum chamber features a port for connecting the medium to be measured. The surface of the first housing body and the membrane that form the reference vacuum chamber are coated with an
10 electrically conductive film, for example, gold, and constitute the electrodes of the capacitance measuring cell. The electrodes are lead out, for example, through the first housing body or through the sealing area in the edge zones. The essentially parallel electrode surfaces
15 are spaced apart from 2 μm to 50 μm . Sealing of the membrane in the edge zone against the two housings is preferably achieved through welding, for example, laser welding. Highly suitable and simple to use is also a glass brazing material that is corrosion resistant.
20 Another possibility of achieving a sealing bond is to connect the housing parts diffusively, for example, in the green body state in which the objective is to completely avoid material other than Al_2O_3 .

The measuring cell arrangement according to the invention
25 essentially allows a symmetric design that avoids all stress in the housing. This is particularly important in order to achieve high measurement sensitivity combined with high accuracy and reproducibility. It also allows the utilization of a very thin ceramic membrane which is
30 essential for reliably measuring vacuum pressures lower than 100 mbar, and in particular lower than 10 mbar, by means of capacitive, all-ceramic measuring cells. For this purpose membrane thicknesses of 10 μm to 250 μm are needed, where membrane thicknesses of 10 μm to 120 μm are
35 preferred in order to achieve a very good resolution. Typical membrane thicknesses are, for example:

- at 1000 Torr: membrane thickness 760 $\mu\text{m} \pm 10 \mu\text{m}$

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- at 100 Torr: membrane thickness $345 \mu\text{m} \pm 10 \mu\text{m}$
- at 10 Torr: membrane thickness $150 \mu\text{m} \pm 10 \mu\text{m}$
- at 1 Torr: membrane thickness $100 \mu\text{m} \pm 10 \mu\text{m}$
- at 0.1 Torr: membrane thickness $60 \mu\text{m} \pm 10 \mu\text{m}$
- 5 • at 0.01 Torr: membrane thickness $40 \mu\text{m} \pm 10 \mu\text{m}$

Such thin membranes are very difficult to manufacture and after the sinter step require at least one additional smoothing step. It is also very important for the membrane to be sufficiently helium tight which can be
10 achieved only if the grain size of the membrane material is not too large and remains within the range of $<20 \mu\text{m}$. Smaller grain sizes of $<10 \mu\text{m}$ are preferred, in particular those $<5 \mu\text{m}$. In all cases the cross-section of the membrane viewed across the thickness should
15 contain at least two grains; the membranes are particularly tight if more than five grains are on top of each other.

Another important criterion for achieving an accurate measuring cell is the planarity of the membrane surface.
20 The unevenness across the entire surface should in all cases not exceed 30% of the electrode gap, preferably not more than 15%. This means that the unevenness across the entire surface should not exceed $10 \mu\text{m}$, preferably no more than $5 \mu\text{m}$. The unevenness is defined here as the
25 difference between the lowest and the highest point. To achieve the desired long-time stability the purity of the aluminum oxide used for the membrane should be at least 94%, with preferred values being above 99%.

To ensure that the quality of the membrane seal in the
30 edge zone is not impaired, it is advantageous to lead out the electrically conductive layers via feedthroughs that are arranged on the first housing body, rather than directly through the membrane seal or fused joint.

To ensure accurate functioning of the measuring cell over a long period of time, the reference vacuum chamber must have a high-quality vacuum with long-time stability. After evacuation a getter should be provided that is preferably arranged in a small volume on the first housing and communicates with the reference vacuum chamber. This getter ensures that the reference vacuum pressure is lower, preferably by at least one decade, than the pressure to be measured. To prevent contaminations of the internal measuring cell space a getter type that is not evaporating should be chosen.

Measuring cells designed according to the invention can be very compact and economical to produce. The diameter of such a cell can be between 5 and 80 mm where the measuring cell preferably has a diameter of 5 to 40 mm. The thickness of such a cell is preferably in the range of 2 mm to 25 mm.

For manufacturing a functional measuring cell that possesses the aforementioned characteristics the specifications of the corresponding manufacturing process must be closely followed. In particular the manufacture of thin ceramic membranes requires special care. The membrane as well as the complete unit should be entirely free of internal stress.

Suitable Al_2O_3 membranes are manufactured, as is usual in the ceramic industry, by first mixing a slurry according to a specific recipe, and by thinly and evenly spreading the doughy mass on a strip shaped carrier material, for example, a plastic foil. After drying these layers are inspected for irregularities such as bubbles or pits. This mass which is not sintered yet is referred to as the green body. The desired membrane shape is cut out of the strip shaped green body material after which the material is still sticking to the plastic foil. For cutting, tools such as knives are used, preferably a laser. Cutting or scoring of the green body requires particular care that no dislocations or warping against the surfaces of the

future ceramic membrane occur as this also influences the degree of surface unevenness. If a cutting knife is used, a pressing wheel can be applied on the membrane side which prevents undue warping of the green body.

- 5 Subsequently the preferably circular cut membranes are separated from the foil strip by drawing off the latter, for example, across an edge. The membranes are subsequently sintered in a furnace. For sintering the membranes are preferably placed on hard-sintered, flat
- 10 Al_2O_3 plates that can be stacked on top of each other, and sintered typically at 1630°C . The temperature is gradually raised to 1630°C over a period of approx. 400 minutes which corresponds to a temperature rise of about 4°C per minute. The temperature is then held for a few
- 15 minutes at this level, for example, 6 minutes and then slowly decreased at the rate of about 3°C per minute over 210 minutes to 1000°C , and in a second step with a temperature reduction of about 6°C per minute over about 170 minutes to room temperature. The result is a ceramic
- 20 membrane which in contrast to the green body has a hard pure ceramic structure, and the additives of the green body material have evaporated. After this sintering step the membrane is very uneven and at a diameter of 40 mm has a warpage of several millimeters.
- 25 In this condition the membrane cannot be used due to the strong warpage and internal stress in the material. The membrane must be smoothed in at least one additional step. For this purpose the membrane is again heated in the furnace. The membrane is carefully sandwiched between
- 30 massive and highly planar, hard-sintered Al_2O_3 plates (also "dead", that is, large-grained Al_2O_3) which for a membrane diameter of 40 mm have a weight of several 10 to several 100 grams, or in the example about 60 grams, or are correspondingly weighted down. The temperature is
- 35 slowly increased at 4°C per minute over 390 minutes to approximately 1570°C . After a short dwell time of several minutes, approximately 25 minutes at this temperature, the temperature is lowered slowly at approx. 5°C per

minute over approx. 115 minutes until 1000°C are reached. Subsequently the temperature is lowered at approx. 6°C per minute over about 166 minutes until ambient temperature is attained. After this smoothing step the

5 membrane has only a very small amount of residual warpage of a few tenths of a millimeter. Important in this smoothing step is that the temperature is not raised as high as in the first sintering process, preferably up to a temperature which is at most 100°C lower than the

10 sintering temperature. To achieve excellent results required for the measuring cell to be built, this smoothing heating step must be performed at least twice. For reasons of economy these smoothing steps should be performed in such a way that no more than two such steps

15 are needed. Particularly good results are achieved when the membrane is carefully separated from the plate between heating steps and redeposited in a slightly offset position. Preferably the membrane is even placed upside down. The utilization of a stack of several flat

20 plates with membranes sandwiched in between is particularly economical. After these steps, membranes are now available that have selectable thicknesses in the range of 10 μm to 250 μm , preferably <120 μm . With the process described above membrane planarities can be

25 achieved that are better than 10 μm across the entire surface, preferably even better than 5 μm . The mean grain size in the membrane material is less than 20 μm , preferably less than 10 μm , and even less than 5 μm is achievable. In this way the requirement that at least 2

30 grains, preferably at least five grains exist across the thickness, can easily be achieved. In this way helium-tight membranes, as required for vacuum measuring cell applications, can be produced. The membrane is now ready to be used for building the measuring cell.

35 The membrane as well as a flat surface of the first housing body made of Al_2O_3 are now coated with an electrically conductive film for creating the electrodes. For example, a metallic paint, for example a paint

containing gold, can be used which, for example, is brushed or sprayed, preferably printed on. Another method is to create the electrically conductive layer by means of evaporation coating, preferably by sputter coating. To
5 allow the deposition of an accurate and defined film it is advantageous if, for example, a gold layer that initially is deposited with a relatively large thickness of about 1 μm , is subsequently thinned down in the inner area to approx. 5 nm by means of an etching process,
10 preferably an ion etching or sputter etching process. In this way a thicker edge area is created which can compensate diffusion losses if, for example, a brazing step is performed. A preferred process that is simple to handle in practice is to first deposit a thin layer of
15 several nm across the entire surface and subsequently a thicker layer of gold at the edge by means of screen printing (that is, a combination process and different film thicknesses). Membranes or housings processed in such a way are subsequently tempered at temperatures of
20 several 100°C, preferably in the range of 650°C.

The second ceramic housing which is arranged on the measurement side consists of a flat ceramic plate which on the membrane side can have a flat recess in order to form a sufficiently large vacuum chamber. The connection
25 port is connected to this ceramic housing by means of brazing, bonding or gluing, preferably by means of glass brazing, in such a way that the connection opening can communicate with the future measurement vacuum chamber.

In the peripheral area where the seal is created the
30 membrane is coated on both sides with a glass paste, preferably by means of screen printing. After drying the membrane with the glass paste is baked in an oven at several 100°C, preferably at about 670°C. Subsequently the glass surface is polished on both sides and thereby
35 preferably also the future electrode spacing is defined.

With the aid of said coating process the upper ceramic housing on the electrode side can on the external surface

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additionally be coated with an electrically conductive film in order to achieve shielding. Also here the connection points are formed on the housing. In an additional step the drill holes for the electrical
5 feedthrough of the electrode connections are metallized, preferably with silver.

In a test phase the first housing with the electrode and the feedthroughs, together with the deposited membrane, is checked for tightness and for correct electrode
10 distance. Subsequently the lower housing part is mounted and the entire assembly is loaded with weight in order to test the function and distances. In a mounting frame the getter connection may additionally be mounted and under a load weight of about 200 grams the glass seals are baked
15 at several 100°C, preferably about 630°C. Subsequently a test is performed to check that the required distances are maintained. If necessary the membrane spacing can be corrected through additional weight loading or relieving and an additional firing process. The sealing process
20 must be executed very carefully and as mentioned, no stress should occur in the measuring cell arrangement. Alternatively also direct bonding can be used in place of glass or other sealants, preferably laser bonding.

The various features of novelty which characterize the
25 invention are pointed out with particularity in the claims annexed to and forming a part of this disclosure and are entirely based on the Swiss priority application no. 1997 2950/97 filed December 23, 1997.

The invention provides a capacitive vacuum measuring cell with a first housing
30 body (1) made of Al_2O_3 with a membrane (2) arranged at a small distance from said housing body with an edge seal in such a way that in between a reference vacuum chamber (25) is created where the surfaces of membrane (2) and the housing body (1) located at a small distance opposite
35 each other are coated with an electrically conductive material (7) and constitute the measuring capacitance, and where a second housing body (4) made of Al_2O_3 and

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featuring an edge seal is located opposite membrane (2) which together with said membrane forms a measurement vacuum chamber (26) in which ports (5) are provided for connecting the medium to be measured, and that the first
5 housing body (1) and second housing body (4) are sealed with the intermediate membrane (2) symmetrically at the edge and the surface unevenness of the membrane (2) is not more than 30 % of the electrode spacing and this lies within the range 2 μm to 50 μm , whereby the membrane (2)
10 has a thickness in the range 10 μm to 250 μm with a mean particle size of the membrane material of $\leq 20 \mu\text{m}$ and that at least two grains are present in the cross-section of the membrane (2) across the thickness, with the diameter of the cell in the range 5 to 80 mm.

15 The invention is described schematically based on the following illustrations which serve as examples:

Fig. 2 shows a schematic cross-section of a capacitive vacuum measuring cell according to the invention.

Fig. 3 shows an enlarged cross-sectional detail according
20 to Fig. 2.

Fig. 4 shows a cross-sectional detail of a getter arrangement

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Fig. 5 shows a cross-section of another getter arrangement version.

A capacitive measuring cell made of Al_2O_3 according to the invention with a structure essentially symmetrical about the membrane is illustrated by the cross-section in Fig. 2. The first housing (1) consists of a ceramic plate made of Al_2O_3 , which along its edges is tightly bonded at a distance of 2 μm to 50 μm relative to the ceramic membrane (2) and which encloses a reference vacuum (25). The distance between the two surfaces is usually established directly during the assembly by means of the sealing material (3) located between the membrane edge and the housing. In this way a completely plane housing plate (1) can be used. In the same way a measurement vacuum chamber (26) is formed in a second housing (4) on the opposite membrane side; this vacuum chamber is accessible for the media to be measured via a connecting port (5) through an opening in the housing (4).

Fig. 3 shows an enlarged cross-sectional detail of the edge zone of a measuring cell. The seal (3) on both sides of the membrane (2) defines, as mentioned above, the distance of the two housings (1 and 4). This seal consists, for example and preferably, of glass paste that is easy to handle and can, for example, be applied by means of screen printing. In a typical measuring cell with an external diameter of 38 mm and a free internal membrane diameter of 30 mm the distance (3) is approx. 2 to 50 μm , preferably 12 to 35 μm . In this example the first housing (1) has a thickness of 5 mm, the second housing (4) a thickness of 3 mm. The inner area of the second housing (4) is preferably designed with an approx. 0.5 mm deep recess, as shown in Fig. 2, in order to enlarge the measurement vacuum chamber (26). On the reference vacuum side the membrane (2) and the housing (1) are each coated with an electrically conductive film (7). These two films are not electrically interconnected. Films (7) can, for example, be painted on, printed on,

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sprayed on, or be deposited by means of a vacuum process. Preferably they are deposited by a vacuum process such as by evaporation coating or sputtering. Particularly suited as a film material is gold which is deposited, for
5 example, with a film thickness of 1 μm and is subsequently thinned down to a few nanometers, preferably to 5 nm, by means of sputter etching. In this way the film thickness can be defined so that it is thin enough and is free of stress. The electrical connections of the
10 membranes (7) are preferably established with vacuum-tight, electrically conducting feedthroughs (6), preferably through the housing (1) where they can subsequently be connected to the evaluation electronics.

To ensure that the reference vacuum in chamber (25)
15 maintains long-time stability, a getter (10) is provided as illustrated in Fig. 4. This getter is preferably a non-evaporating getter in order to keep the reference vacuum chamber (25) free from evaporating particles. On housing (1) a getter space (13) which accommodates the
20 getter (10) is provided which communicates via connection (14) or an evacuation line with the reference vacuum chamber (25). The getter space (13) can also be mounted on top of housing (1), but is preferably recessed in housing (1). While the reference vacuum chamber (25) is
25 being pumped down via evacuation line (14), the getter space (13) is also connected to the pumping device. This is achieved by lifting the cover (8) with getter (10) a certain distance from the surface of the housing (1) and thus providing an opening. Cover (8) made of metal or
30 ceramic is heated up during the evacuation process, causing the getter to be activated and simultaneously degassed. After the getter has been activated cover (8), with sealing material (9) between cover (8) and housing (1), is pressed tightly against the housing during the
35 evacuation process. The sealing material (9) can, for example, be diffusive, a brazing material or preferably a glass brazing material. Retaining spring (11) which

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presses the getter against cover (8) ensures that the getter has good thermal contact with the cover (8).

Another version of a getter arrangement is illustrated in Fig. 5 where a contacting agent (12), preferably a
5 brazing material, is placed between getter (10) and cover (8) in order to achieve better thermal contact. Excellent thermal conductivity is required here so that the getter (10) can be thermally activated via the cover (8) from the outside. In addition this getter arrangement allows
10 activation of the getter and subsequent brazing of the cover (8) in a single work step, provided the activation temperature of getter (10) and the brazing temperature of the brazing material (9) are essentially the same.

Summary:

The present inventions relates to a capacitive vacuum measuring cell which essentially is built completely of ceramic material and therefore has a high degree of corrosion resistance. For measuring very low pressures with high accuracy an extremely thin ceramic membrane with a thickness of $<250\text{ }\mu\text{m}$ is used that is free of stress and arranged symmetrically in a ceramic housing.

Patent claims:

1. Capacitive vacuum measuring cell with a first housing
body (1) made of Al_2O_3 , with a membrane (2) arranged at a
small distance from said housing body with an edge seal
5 in such a way that in between a reference vacuum chamber
(25) is created where the surfaces of membrane (2) and
the housing body (1) located at a small distance opposite
each other are coated with an electrically conductive
material (7) and constitute the measuring capacitance,
10 and where a second housing body (4) made of Al_2O_3 , and
featuring an edge seal is located opposite membrane (2)
which together with said membrane forms a measurement
vacuum chamber (26) in which ports (5) are provided for
connecting the medium to be measured, and that the first
15 housing body (1) and second housing body (4) are sealed
with the intermediate membrane (2) symmetrically at the
edge and the surface unevenness of the membrane (2) is
not more than 30 % of the electrode spacing and this lies
within the range 2 μm to 50 μm , whereby the membrane (2)
20 has a thickness in the range 10 μm to 250 μm with a mean
particle size of the membrane material of $\leq 20 \mu\text{m}$ and that
at least two grains are present in the cross-section of
the membrane (2) across the thickness, with the diameter
of the cell in the range 5 to 80 mm.
- 25 2. Measuring cell according to claim 1 where the
electrodes (7) that enclose reference vacuum chamber (25)
and which constitute the measurement capacitance are
arranged at a distance of 12 μm to 35 μm .
3. Measuring cell according to claim 1 or 2 where the
30 connection is implemented by fusion, by diffusion bonding
or preferably by brazing, in particularly with glass
brazing material.
4. Measuring cell according to claims 1 to 3 where
membrane (2) has a thickness in the range of 10 μm to 120
35 μm .

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5. Measuring cell according to claim 4 where the mean grain size of the membrane material is $\leq 10 \mu\text{m}$, in particular $\leq 5 \mu\text{m}$.
6. Measuring cell according to claim 4 or 5 where in the cross-section of membrane (2) at least five grains exist across the thickness.
7. Measuring cell according to one of the preceding claims where the areal unevenness of membrane (2) is not greater than 15%.
8. Measuring cell according to one of the preceding claims where the areal unevenness of membrane (2) is not greater than $10 \mu\text{m}$, preferably not greater than $5 \mu\text{m}$.
9. Measuring cell according to one of the preceding claims where the purity of the Al_2O_3 of membrane (2) is at least 94%, preferably at least 99%.
10. Measuring cell according to one of the preceding claims where the contacts to the electrically conductive layers (7) are lead out through sealed feedthroughs (6) on the first housing body (1).
11. Measuring cell according to one of the preceding claims, characterized by having a volume (13) with a getter (10) on or in the first housing (1), with a connection (14) provided between volume (13) and the reference vacuum chamber (25) and the volume (13) is sealed with a cover (8).
12. Measuring cell according to claim 11 where the getter is of the "non-evaporating" type.
13. Measuring cell according to claim 11 or 12 where getter (10) within volume (13) is pressed by means of spring (11) against cover (8).
14. Measuring cell according to claim 13 where a contacting material (12), preferably a brazing material, is provided between getter (13) and cover (8).

15. Measuring cell according to one of the preceding claims where the pressure in the reference vacuum chamber (25) is lower than the lowest pressure to be measured, preferably lower by at least one decade.

5 16. Measuring cell according to one of the preceding claims where the cell diameter is in the range of 5 to 40 mm.

17. Measuring cell according to one of the preceding claims where at least one of the surfaces of housings (1, 4) is coated with an electrically conductive film for the purpose of shielding.

18. Process for manufacturing an Al_2O_3 membrane for a measuring cell according to one of the claims 1 to 18 which comprises the following steps:

- 15 • Membranes are formed from an Al_2O_3 slurry,
- this is followed by a first heating step for sintering the membrane in a furnace, with subsequent cool-down,
- 20 • in a second heating step the membrane is reheated and thereby smoothed and subsequently cooled down,
- thereby yielding a membrane with at least two grains over the thickness of the membrane.

19. Process according to claim 18 where a third heating step is performed for smoothing.

20. Process according to claim 19 where the sintering temperature of the first heating step is higher than the temperature of the subsequent smoothing step or steps, where the temperature difference is preferably no more than 100°C.

21. Process according to one of the claims 18 to 20 where membrane (2) is detached from the plates between smoothing steps and redeposited in offset position.

22. Process for manufacturing a measuring cell according to one of the claims 1 to 17 with an Al_2O_3 membrane (2) produced with a process according to one of the claims 18 to 21, comprising the following steps:

- 5 - Manufacture of a first Al_2O_3 housing plate (1) with an electrically conductive surface (7), a connecting opening (14) that interconnects the surfaces of plate (1) and featuring two electrical, vacuum-tight feedthroughs (6) where one feedthrough (6) is
10 electrically connected to the conductive surface (7);
- Manufacturing of a second Al_2O_3 housing plate (4) with a connecting opening that interconnects the surfaces of plate (4) where on plate (4) a sealing connecting port (5) that communicates with the line is installed.
- 15 - Coating of the one membrane surface with an electrically conductive film (7);
- Installation of the plates (1,4) in such a way that membrane (2) is positioned at a certain distance between plates (1,4) and its peripheral edge zone is sealed
20 vacuum tight with plates (1,4) and that the electrically conductive layers (7) of the first plate (1) and the one of the membrane (2) are mutually opposite and constitute the measuring capacitance by defining a reference vacuum chamber (25), where layer (7) on membrane (2) is
25 electrically conductive and connected to the other feedthrough (6) of the first plate (1) and the surface (7) which points away from connection port (5) of the second plate (4) together with membrane (2) defines a measurement vacuum chamber (26);
- 30 - Pumpdown of the reference vacuum chamber (25) by line (14) under activation of a getter (10) that is connected to line (14) where after attainment of the desired vacuum the line (14) with getter (10) is closed vacuum tight (8).

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23. Process according to one of the preceding claims 18
to 22 where the membrane shape is cast or pressed from
the Al_2O_3 slurry, preferably from a ribbon-shaped Al_2O_3
green body supported on a carrier foil, and which is
5 subsequently pulled off the foil.

24. Utilization of the measurement cell according to one
of the preceding claims 1 to 17 for pressures smaller
than 1000 mbar, preferably smaller than 1 mbar, with a
resolution of better than 1%, preferably better than
10 0.3%.