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(54) Title: MEMS BACKPLATE, MEMS MICROPHONE COMPRISING A MEMS BACKPLATE AND METHOD FOR MANUFACTURING A MEMS MICROPHONE

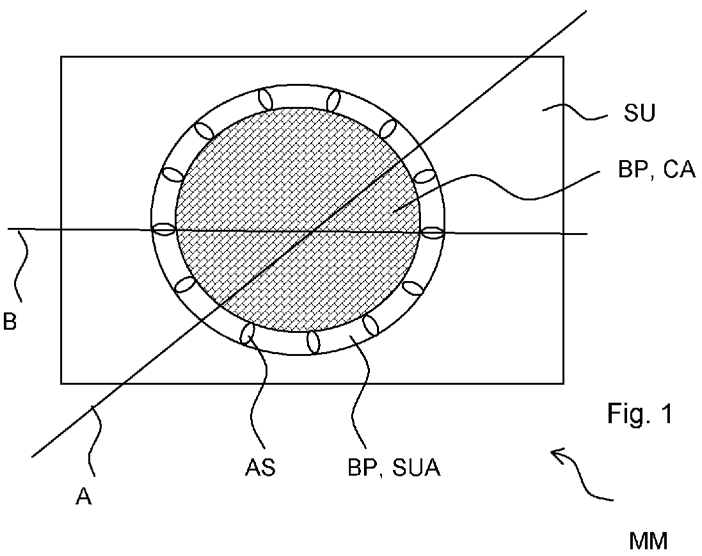

Fig. 1

(57) Abstract: A MEMS backplate enabling MEMS microphones with reduced parasitic capacitance is provided. Therefore, the backplate comprises apertures in a suspension area.

WO 2013/071950 A1

Description

MEMS backplate, MEMS microphone comprising a MEMS backplate and method for manufacturing a MEMS microphone

The present invention relates to MEMS backplates, MEMS microphones with reduced parasitic capacitance and a method for manufacturing such microphones.

MEMS microphones usually comprise a conductive backplate and a conductive, flexible membrane being arranged in a distance from the backplate. The backplate and the membrane realize electrodes of a capacitor. When a bias voltage is applied to the electrodes, then oscillations of the membrane caused by received acoustic signals are converted into electrical signals. For further signal processing MEMS-microphones can comprise an ASIC (Application-specific Integrated Circuit) chip.

Such Microphones have a central, acoustically active area and a suspension area. The central area is surrounded by the suspension area being acoustically inactive. Within the suspension area, suspension means for mechanically and/or electrically connecting the backplate and/or the membrane are arranged on a substrate material. For constructing MEMS microphones, manufacturing processes of semi-conductor devices such as layer deposition, deposition of photo resist films, structuring photoresist films, and partly removing structured layers can be utilized. As a consequence of the necessity for suspension means the capacitor – apart from the central area – has an acoustically inactive area deteriorating the signal quality of the microphone. This deterioration is due to parasitic capacitance. The corresponding signal attenuation H_c is:

$$H_c=C_m/(C_m+C_i+C_p), \quad (1)$$

where C_i is the input capacitance of an according ASIC chip processing the electrical signal. C_p is the parasitic capacitance, i.e. the capacitance of the capacitor's acoustically inactive area. C_m is the total capacitance comprising the capacitance of the central area and the capacitance of the suspension area. Reducing the parasitic capacitance reduces the signal's deterioration and, thus, improves the microphone's signal quality.

C_p mainly depends on the acoustically inactive suspension area of the backplate overlapping a suspension area of the membrane.

It is an object of the present invention to provide a MEMS backplate that can be used in a MEMS microphone having reduced parasitic capacitance, a MEMS microphone with reduced parasitic capacitance and a method for manufacturing such a microphone.

Therefore, the independent claims provide a MEMS backplate, a MEMS microphone and a method for manufacturing such a microphone. Dependent claims provide preferred embodiments of the invention.

A MEMS backplate comprises a central area, a perforation in the central area, a suspension area, and an aperture in the suspension area. The suspension area surrounds the central area at least partially.

In this context, the phrase "perforation" refers to holes in the central area while "apertures" refers to holes in the suspension area of the MEMS backplate. Both categories of holes can be arranged in a regular pattern such as a quadratic pattern or a hexagonal pattern or in a irregular pattern. It is also possible that additional holes at irregular lattice places can be added to the holes of a regular pattern. Such additional holes can have a bigger or smaller diameter. The apertures can be larger than the holes of the perforation, or vice-versa. It is also possible that the apertures have the same size as the holes of the perforation.

The unwanted parasitic capacitance depends on the amount of the acoustically inactive area, i.e. the suspension area, of the backplate and of the membrane. Further, the capacitance depends on the dielectric constant of the material in-between these electrodes.

An aperture in the suspension area of the backplate reduces the acoustically inactive but electrically active amount of conductive area of the backplate resulting in an improved signal quality of the respective MEMS microphone.

The suspension area can comprise two or more, e.g. a plurality of, apertures in the suspension area.

It was found that such a MEMS backplate reduces the parasitic capacitance of a respective MEMS microphone and a mechanically stable microphone can be obtained although the area for suspending the backplate is reduced.

Further, it was found that apertures in the suspension area of the backplate enable methods for manufacturing MEMS microphones with further reduced parasitic capacitances while maintaining the mechanical stability.

In one embodiment, the suspension area surrounds the central area completely. Then, a MEMS backplate is provided that enables an optimal mechanical stability of a respective MEMS microphone.

The MEMS backplate and/or the respective membrane can have a circular or an elliptic shape. It is further possible that the MEMS backplate and the membrane have a rectangular or a quadratic shape.

In one embodiment, the suspension area comprises a plurality of apertures.

In one embodiment, the MEMS backplate comprises a plurality of apertures which are comprised in aperture sections. Thus, the apertures are concentrated in the aperture sections while other sections of the suspension area do not comprise apertures and maintain their mechanical stiffness required for a stable suspension.

Thus, the MEMS backplate can be optimized with respect to electric capacitance and mechanical stability.

In one embodiment, the MEMS backplate has aperture sections which are arranged in equal distances with respect to their neighboring aperture sections. Thus, the aperture sections can be arranged in a symmetric pattern within the suspension area.

A MEMS microphone can comprise one of the above mentioned backplates. The microphone can further comprises a substrate, a membrane, and an anchor element. The membrane is arranged between the substrate and the anchor element. The backplate suspension area is connected to the anchor element.

In one embodiment, the anchor element comprises connection sections. The suspension area of the MEMS backplate comprises aperture sections, each comprising at least one aperture. The connection sections of the anchor element are connected to the backplate suspension area. The backplate aperture sections are, then, arranged above cavities within the anchor element. Corresponding to a symmetry of the arrangement of the aperture sections of the suspension section the connection elements can be arranged using the same symmetry but an offset relative to the pattern of the aperture sections.

It was found that the parasitic capacitance can be reduced by establishing cavities within the anchor element which can comprise dielectric material. The parasitic capacitance depends on the dielectric constant of the anchor element. The absence of dielectric material of the anchor element within the cavities reduces, thus, the parasitic capacitance as vacuum or an ambient atmosphere has a lower dielectric constant than the anchor element's material. As the anchor element still comprises connection sections being connected to the backplate suspension area, a mechanically stable microphone is obtained.

Thus, in one embodiment, the cavities are arranged within the anchor element.

A method for manufacturing a MEMS microphone comprises the steps:

- providing a substrate,
- structuring a membrane on the substrate,
- structuring an anchor element on the membrane,
- structuring a backplate on the anchor element creating a perforation in a central area of the backplate and creating apertures in a suspension area of the backplate,
- removing material of the anchor element in a region below the apertures.

Thus, the apertures within the suspension area of the backplate not only reduce the electrically active area of the capacitor resulting in the parasitic capacitance. The apertures further allow to create cavities within the anchor element as they enable removing material of the anchor element during manufacturing of the MEMS microphone through the aperture holes.

It is possible that material of the anchor element between the backplate and the membrane is removed while material of the anchor element below the aperture sections is removed.

In one embodiment of the method, material of the anchor element is removed using a VHF (Vapor Hydro-Fluoric) etching environment.

The basic idea of the invention and embodiments are shown in the schematic figures.

Brief description of the figures:

FIG. 1 shows a top view onto a MEMS microphone indicating the positions of cross-section A and cross-section B,

FIG. 2A shows cross-section A indicated in FIG. 1,

FIG. 2B shows the cross-section B indicated in FIG. 1,

FIG. 3 shows an enlarged view of the rim of a backplate,

FIG. 4 shows an anchor element comprising cavities.

FIG. 1 shows a top view of a MEMS microphone MM. The microphone MM comprises a substrate SU on which a backplate BP is arranged. Backplate BP comprises a central area CA and a suspension area SUA. The suspension area SUA surrounds the central area CA. The central area CA is the acoustically active area of the backplate BP while the suspension area SUA is acoustically inactive and, due to the contribution of the parasitic capacitance C_P in equation (1), generally deteriorates the microphone's signal quality. However, the backplate BP comprises aperture sections AS within the suspension area SUA. The aperture sections AS comprise apertures as shown in FIG. 3. Due to the apertures in the aperture sections AS, the acoustically inactive but electrically active suspension area SUA is reduced. Thus, parasitic capacitance C_P is reduced.

Further, the apertures in the aperture sections AS allow to create MEMS microphones with further reduced parasitic capacitances: during a manufacturing step, material of an anchor element below the backplate BP can be removed via the apertures of the aperture sections. This is shown in FIGs. 2A and 2B which illustrate cross-sections A, B.

The aperture sections AS can be arranged in equal distances with respect to their neighboring aperture sections AS.

FIG. 2A shows cross-section A illustrated in FIG. 1. The MEMS microphone comprises a membrane M being arranged on substrate SU. An anchor element AE is arranged on membrane M. The backplate BP is arranged on the anchor element AE. Connection sections CS of the anchor element AE are connected to the suspension area SUA of backplate BP. Thus, a mechanically stable connection between the backplate BP and the body of the microphone is obtained. A perforation PF of the acoustically active region of the backplate BP comprises holes.

FIG. 2B shows cross-section B illustrated in FIG. 1. Cross-section B intersects aperture sections AS within the suspension area SUA.

The aperture sections AS comprise apertures AP. Below the apertures AP, material of the anchor element AE, shown in FIG. 2A, is removed. Thus, cavities CV below the aperture sections AS are obtained. Correspondingly, the parasitic capacitance is reduced as dielectric material having a larger dielectric constant than air or vacuum is replaced by air or vacuum within the cavities CV.

FIG. 3 shows an enlarged view of the rim of a backplate BP. The perforation PF comprises holes HO. Holes HO are arranged in a hexagonal pattern. However, other patterns such as rectangular or quadratic patterns or irregular patterns are also possible. Aperture section AS comprises a plurality of apertures AP. The aperture section AS, and thus the apertures AP, are arranged within the suspension area SUA which serves as a connection means to connect the backplate BP to the body of the MEMS microphone, e. g. via an anchor element AE.

The apertures AP within the aperture section AS can also be arranged in a hexagonal, rectangular, quadratic or irregular pattern. The aperture sections AS themselves can have a circular, rectangular, quadratic or irregular shape.

The holes HO of the perforation can be larger than the apertures within the aperture sections, or vice-versa. It is also possible that the apertures AP and the holes HO of the perforation PF have the same size.

It is possible that apertures AP and holes HO are created during the same manufacturing step.

FIG. 4 shows a circular shaped anchor element AE comprising cavities CV. The cavities CV reduce the average dielectric constant of the anchor element AE reducing the parasitic capacitance C_P. The position and size of cavities CV can be optimized with respect to mechanical stability and reduced parasitic capacitance simultaneously.

A MEMS backplate, a MEMS microphone or a method for manufacturing such microphones are not limited to the embodiments described in the specification or shown in the figures. Backplates comprising further structured elements and microphones comprising further layers and methods for manufacturing microphones comprising further manufacturing steps are also comprised by the present invention.

List of reference signs:

A: cross-sections through solid sections of anchor element
AE: anchor element
AP: aperture
AS: aperture section
B: cross-sections through aperture sections
BP: backplate
CA: central area
CS: connection section
CV: cavity
HO: hole of perforation PF
M: membrane
MM: MEMS microphone
PF: perforation
SU: substrate
SUA: suspension area

Claims

1. A MEMS backplate (BP), comprising
- a central area (CA), a perforation (PF) in the central area (CA),
- a suspension area (SUA), and an aperture (AP) in the suspension area (SUA), where
- the suspension area (SUA) surrounds the central area (CA) at least partially.

2. The MEMS backplate of the previous claim, where the suspension area (SUA) surrounds the central area (CA) completely.

3. The MEMS backplate of one of the previous claim, where the suspension area (SUA) comprises a plurality of apertures (AP).

4. The MEMS backplate of the previous claim, where the plurality of apertures (AP) are comprised in aperture sections (AS).

5. The MEMS backplate of the previous claim, where the aperture sections (AS) are arranged in equal distances with respect to their neighboring aperture sections (AS).

6. A MEMS microphone (MM) comprising a MEMS backplate (BP) of one of the previous claims, further comprising
- a substrate (SU), a membrane (M), and an anchor element (AE), where
- the membrane (M) is arranged between the substrate (SU) and the anchor element (AE),

- the backplate’s suspension area (SUA) is connected to the anchor element (AE).

7. The MEMS microphone of the previous claim, where
- the anchor element (AE) comprises connection sections (CS),
- the suspension area (SUA) comprises aperture sections (AS),
- the connection sections (CS) are connected to the backplate’s suspension area (SUA), and
- the backplate’s aperture sections (AS) are arranged above cavities (CV).

8. The MEMS microphone of the previous claim, where the cavities (CV) are arranged within the anchor element (AE).

9. A Method for manufacturing a MEMS microphone, comprising the steps
- providing a subtrate (SU),
- structuring a membrane (M) on the substrate (SU),
- structuring an anchor element (AE) on the membrane (M),
- structuring a backplate (BP) on the anchor element (AE) creating a perforating (PF) a central area (CA) of the backplate (BP) and creating apertures (AP) in a suspension area (SUA) of the backplate (BP),
- removing material of the anchor element (AE) in a region below the apertures (AP).

10. The Method of the previous claim, where material of the anchor element (AE) is removed using a VHF etching environment.

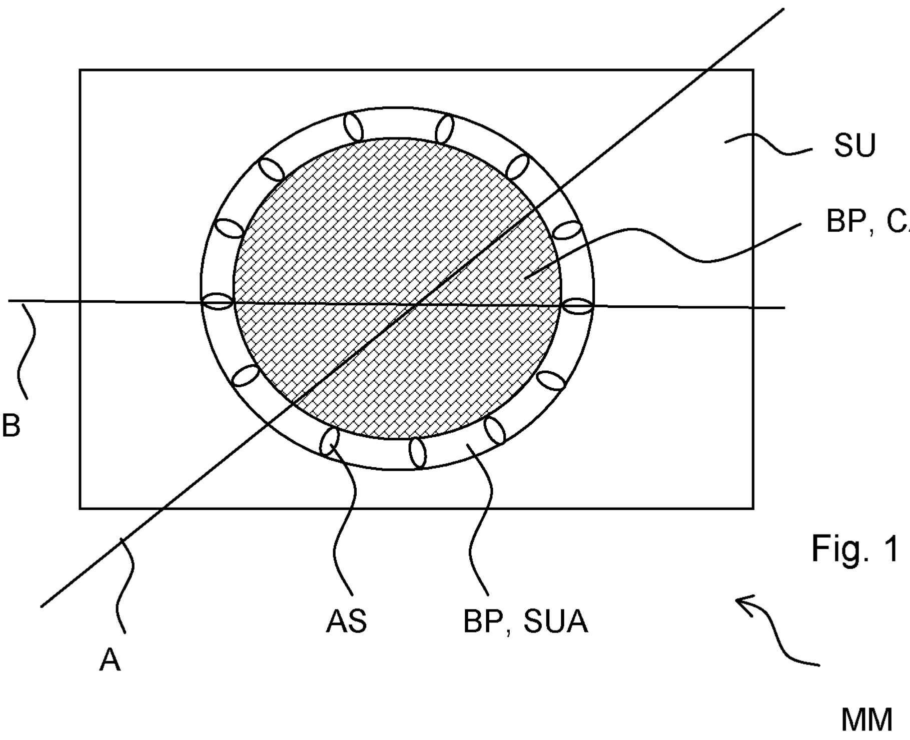

Fig. 1

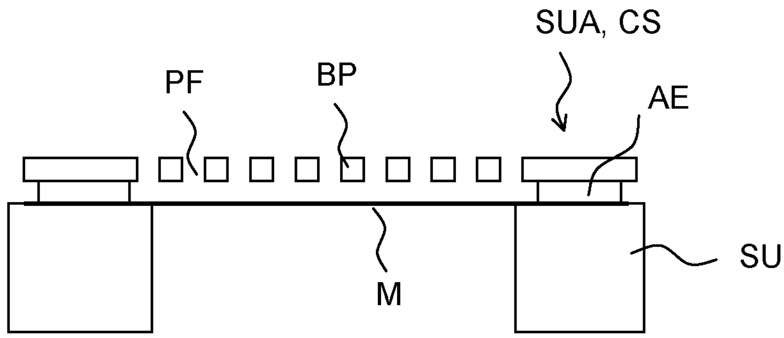

Fig. 2A

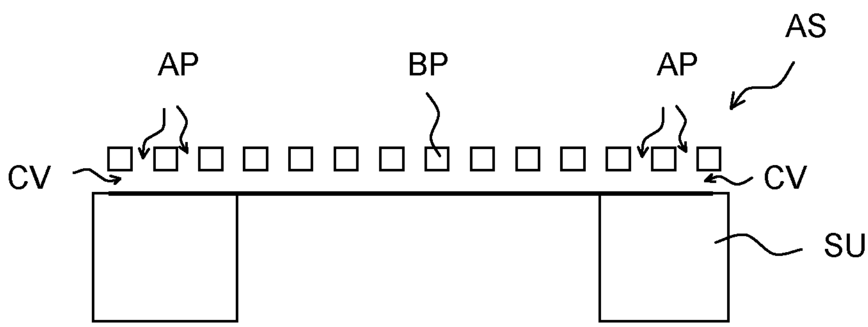

Fig. 2B

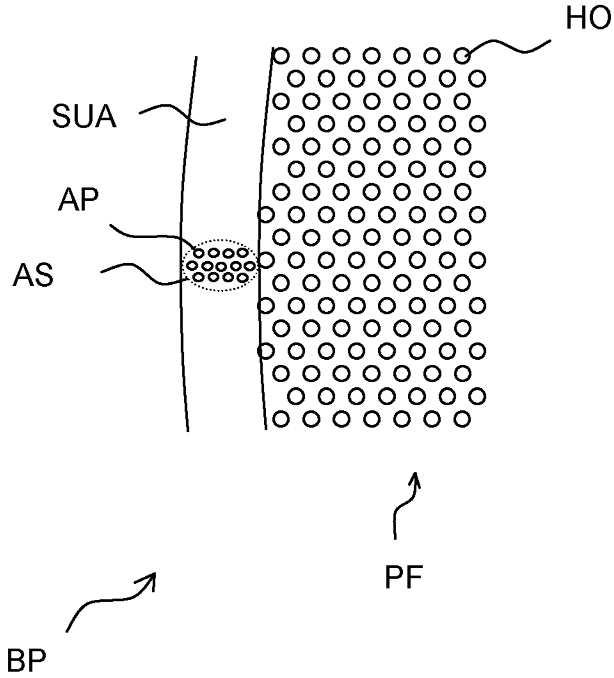

Fig. 3

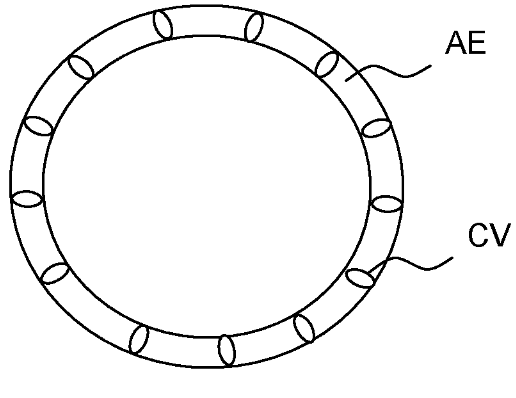

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/070067

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R19/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/201710 A1 (SUZUKI YUKITOSHI [JP] ET AL) 30 August 2007 (2007-08-30) paragraphs [0396] - [0398]; figures 44-45 -----	1-10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 March 2012	23/03/2012

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2011/070067

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007201710 A1	30-08-2007	KR 20080090555 A	08-10-2008
		US 2007201710 A1	30-08-2007
		WO 2007100068 A1	07-09-2007