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(54) Title: A PRESSURE SENSOR

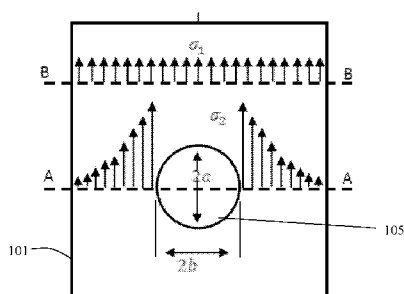
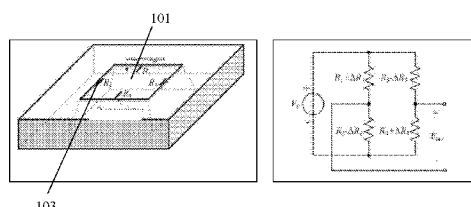


Figure 1



(a)

(b)

Figure 2

(57) **Abstract:** The present invention relates to a pressure sensor comprising: a diaphragm (101) as a mechanical deforming structure when pressure applied onto; a resistor (103) to measure the change in resistance and produce electrical output due to the change in stress level upon the deformation of the diaphragm (101); characterized in that the diaphragm (101) comprising a hole (105) etched on the diaphragm (101) configured to amplify and concentrate the stress level on the diaphragm (101) upon the deformation, producing the highest stress region at the edge of the diaphragm (101).

**Declarations under Rule 4.17:**

- *as to the identity of the inventor (Rule 4.17(i))*
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Description

Title of Invention: A PRESSURE SENSOR

[1] **FIELD OF INVENTION**

[2] The present invention relates to a device that detects external pressure presents in surroundings.

[3] **BACKGROUND OF THE INVENTION**

[4] Pressure sensor is one of the most successful MEMS/NEMS products and has undergone a significant increase of demand in various types of application such as automotive, healthcare, biomedical, aquaculture and environmental monitoring applications. The pressure sensor works on the principle of mechanical deformation of diaphragm when the pressure is applied at the surface diaphragm. During the deformation, the diaphragm would experience the surface stress difference which proportionally with the magnitude of pressure applied. In common practice, the piezoresistor that connected together in the form of Wheatstone Bridge Circuit would be used as a sensing element to electrically translate the stress into meaningful pressure signal. Therefore, based on this principle work, the diaphragm design that can give a high stress difference during application of measurement is desirable especially applications

[5] requiring very high sensitive pressure. At present, there are several available methods is used to increase the pressure sensor sensitivity which are 1) Fabricate a thin film diaphragm - Well known method to increase the pressure sensor sensitivity is by fabricating the sensor diaphragm as thin as possible in order to maximize the load deflection response. However the thin diaphragm will result the nonlinear effect which are not desirable for high accuracy applications. 2) Introduce of structures on diaphragm - Deposit the structure on the diaphragm can amplify the stress that concentrates between the joining part (diaphragm part and structure part). However, additional structure on diaphragm will increase the diaphragm stiffness properties which in turn would make the diaphragm hard to deform. Thus it is not suitable for the low pressure applications. 3) Fabricate a multi level thickness of diaphragm - Multi level thickness of diaphragm would produce a multiple spot and wide range of high stress level. However, the fabrication process for the multi level diaphragm is very complex. Moreover, the piezoresistor need to attach from the centre to the pressure sensor edges which (usually only at the edges of pressure sensor) would also increase the diaphragm stiffness.

[6] **SUMMARY OF THE INVENTION**

[7] According to an aspect of the present invention, the present invention provides a pressure sensor comprising: a diaphragm (101) as a mechanical deforming structure when pressure applied onto; a resistor (103) to measure the change in resistance and

produce electrical output due to the change in stress level upon the deformation of the diaphragm (101); characterized in that the diaphragm (101) comprising a hole (105) etched on the diaphragm (101) configured to amplify and concentrate the stress level on the diaphragm (101) upon the deformation, producing the highest stress region at the edge of the diaphragm (101).

- [8] The above provision is advantageous as it introduces a Stress Concentration Region (SCR) in the form of holes on diaphragm surface in order to increase the surface stress difference when the pressure is applied. The hole introduced on the pressure sensor diaphragm would create a discontinuity in surface pressure sensor diaphragm. Hence, when a load pressure is applied on the diaphragm, the diaphragm would experience a high stress difference that would concentrate in hole vicinity. Therefore, by proposing this technique, the pressure sensor sensitivity can be increased without compromising with the linearity, deflection response and the stiffness properties.

[9] **BRIEF DESCRIPTION OF THE DRAWINGS**

- [10] **Figure 1** illustrates stress distribution diagram of the diaphragm (101) of the present invention.

- [11] **Figure 2** illustrates (a) the location of the resistors (103), and (b) its location of the present invention.

- [12] **Figure 3** illustrates one of the embodiments of the present invention.

- [13] **Figure 4** illustrates the simulation result that shows the SCR hole gives the highest stress region at the edges of pressure sensor membrane.

- [14] **Figure 5** illustrates the simulation result that shows the stress comparison between different depths of SCR hole on the diaphragm structure.

[15] **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT**

- [16] Generally, the present invention relates to a pressure sensor comprising: a diaphragm (101) as a mechanical deforming structure when pressure applied onto; a resistor (103) to measure the change in resistance and produce electrical output due to the change in stress level upon the deformation of the diaphragm (101); characterized in that the diaphragm (101) comprising a hole (105) etched on the diaphragm (101) configured to amplify and concentrate the stress level on the diaphragm (101) upon the deformation, producing the highest stress region at the edge of the diaphragm (101).

- [17] In view of that, the present invention tends to overcome the aforementioned issue by using SCR technique where the hole (105) is introduced on the diaphragm (101). By introducing the hole (105) on the diaphragm (101) it would result the discontinuity thus amplifies the surface stress in the hole vicinity. The hole (105) can be round, or square, or oval of shape. The hole (105) is etched at the depth of range of 10-90% of the thickness of the diaphragm (101). The aforementioned SCR maybe only a simple circle hole at any place of plate and the plate is subjected to uniform tensile load at the

free ends as shown in **Figure 1**. Stress distribution at a section A-A passing through the hole (105) and another section B-B away from the hole (105). Stress distribution away from the hole (105) is uniform but at section A-A, there is a sharp rise in stress in the vicinity of the hole. Sharp rise at section A-A is described as highest surface stress region and denoted as where it can be expressed as followed (Joshi et al, 2007). So, based on this potential concept, it shows that by introducing a hole on a diaphragm for the pressure sensor application, it amplifies the stress at hole vicinity due to applied pressure. Hence this approach is very beneficial to get a high sensitive pressure sensor. Preferably, the present invention is incorporated with a group of resistors that connected together in the form of Wheatstone Bridge circuit as shown in **Figure 2**. The diaphragm (101) structure must be

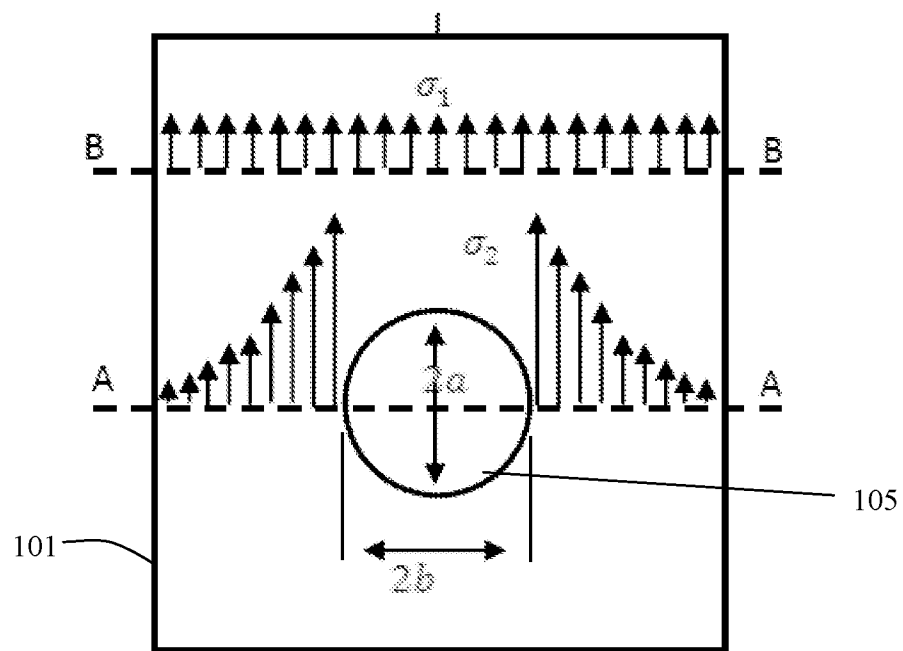
[18] encapsulated so it can measure the pressure from the top or bottom without pressure leak. This resistor (103) is attached at the centre of the edge of the diaphragm (101) where this region usually would have high stress region. Hence, in this invention, a hole (105) would be introduced at each diaphragm edges in order to amplify this stress region. **Figure 3** shows the hole (105) that is introduced at the diaphragm (101). So that, by attaching the resistor (103) in this high level stress concentration region, it proportionally increases the electrical output voltage thus the increase the pressure sensor sensitivity. **Figure 4** is the simulation result that shows the SCR hole gives the highest stress region at the edges of pressure sensor membrane while **Figure 5** is simulation result that shows the stress comparison between different depth of SCR hole on the diaphragm structure.

[19] Although the invention has been described with reference to particular embodiment, it is to be understood that the embodiment is merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be made to the illustrative embodiment that other arrangements may be devised without departing from the scope of the present invention as defined by the appended claims.

Claims

- [Claim 1] A pressure sensor comprising:
a diaphragm (101) as a mechanical deforming structure when pressure applied onto;
a resistor (103) to measure the change in resistance and produce electrical output due to the change in stress level upon the deformation of the diaphragm (101);
characterized in that
the diaphragm (101) comprising a hole (105) etched on the diaphragm (101) configured to amplify and concentrate the stress level on the diaphragm (101) upon the deformation, producing the highest stress region at the edge of the diaphragm (101).
- [Claim 2] A pressure sensor as claimed in Claim 1, wherein the resistor (103) is located at the highest stress region.
- [Claim 3] A pressure sensor as claimed in Claim 1, wherein the hole (105) is etched at the depth of range of 10-90% of the thickness of the diaphragm (101).
- [Claim 4] A pressure sensor as claimed in Claim 1, wherein the diaphragm (101) is encapsulated.

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**Figure 1**

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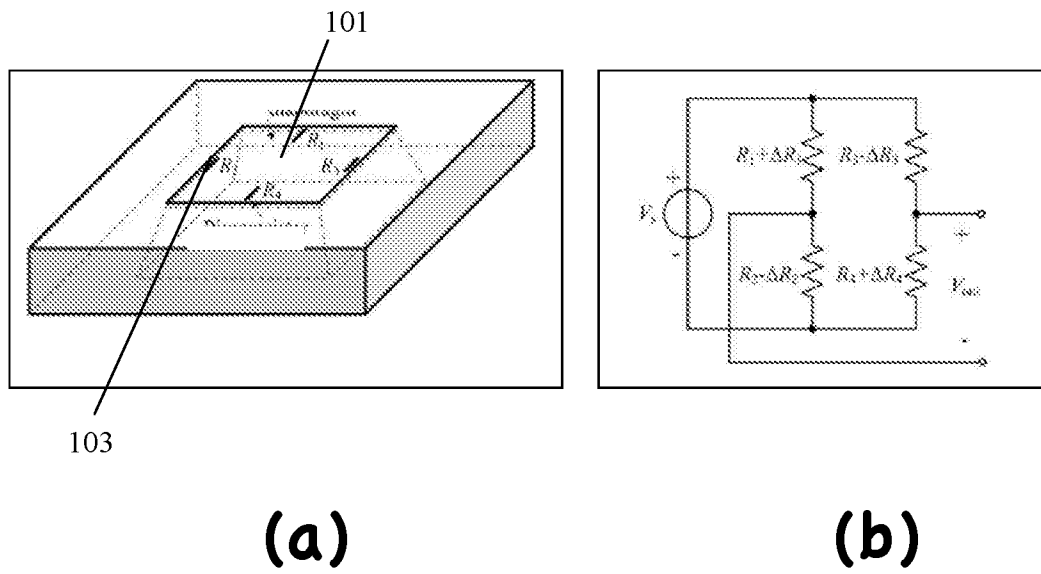


Figure 2

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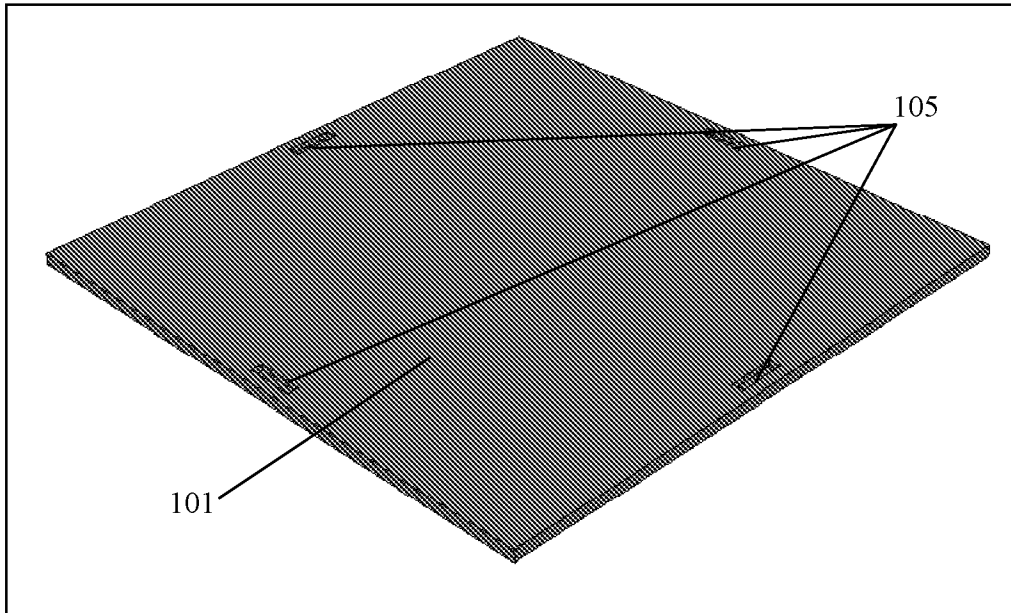


Figure 3

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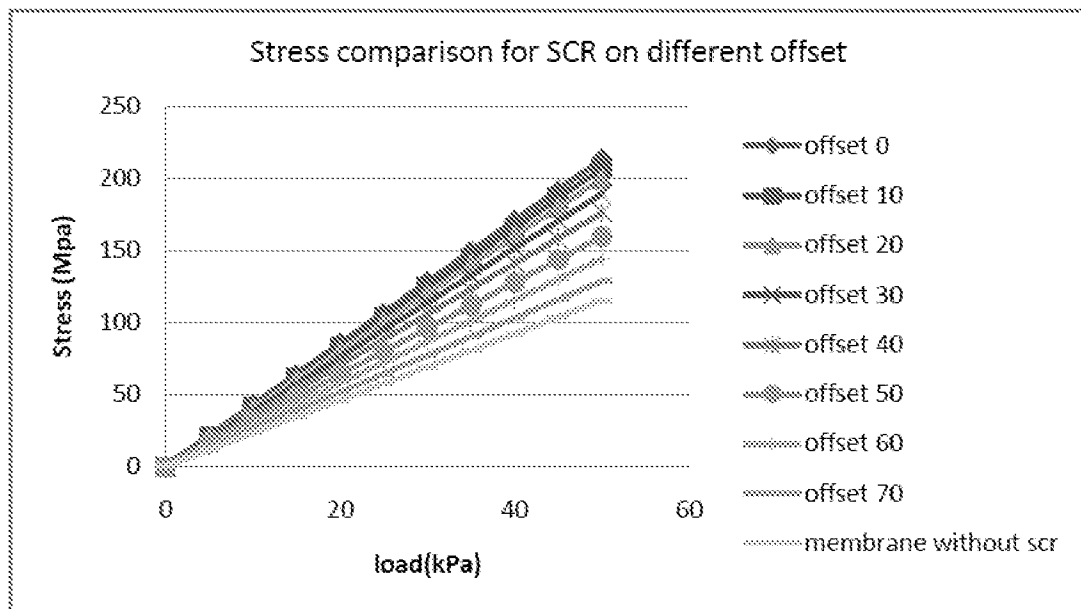


Figure 4

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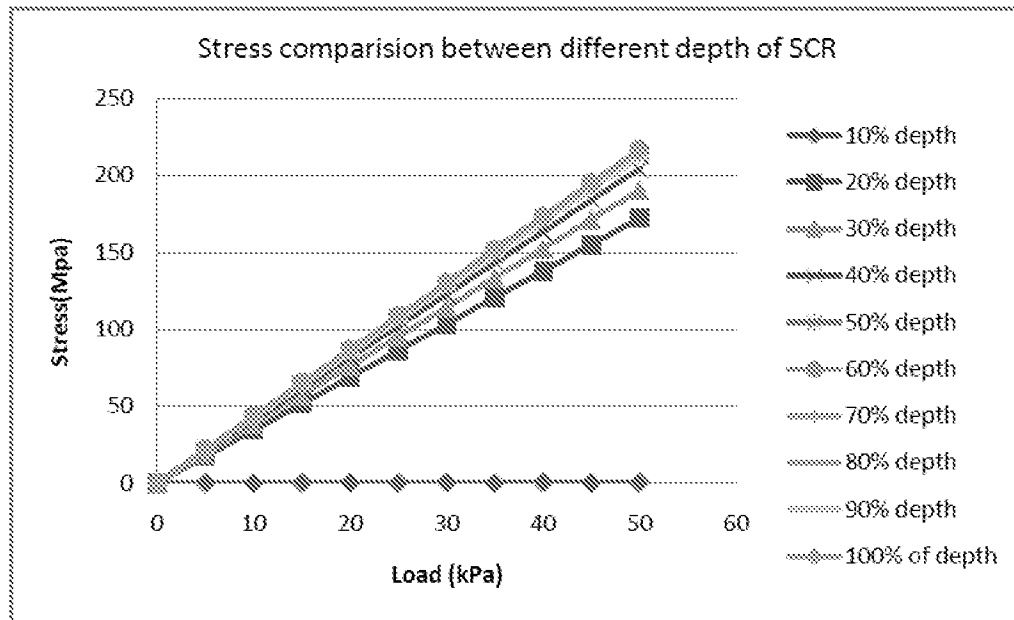


Figure 5

INTERNATIONAL SEARCH REPORT

International application No

PCT/MY2013/000270

A. CLASSIFICATION OF SUBJECT MATTER

INV. G01L9/00

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)

G01L

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 practicable, 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	WO 2011/083158 A2 (ELMOS SEMICONDUCTOR AG [DE]; TEN HAVE ARND DR [DE]) 14 July 2011 (2011-07-14) abstract figures 1,2,4,9,10,16, 20-32, 39 page 1, lines 1-5 page 2, line 21 - page 3, line 3 page 3, lines 25-28 page 4, lines 4-10 page 9, lines 4-5 page 10, line 14 - page 11, line 8 page 13, lines 15-16 page 37, lines 11-12 page 38, lines 17-18 page 40, lines 13-15 ----- -/-	1-4



Further documents are listed in the continuation of Box C.



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"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search

29 April 2014

Date of mailing of the international search report

12/05/2014

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Schambach, Philip

INTERNATIONAL SEARCH REPORT

International application No
PCT/MY2013/000270

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MUHAMMAD ANIQ SHAZNI MOHAMMAD HANIFF ET AL: "The design and analysis of a proliferated-membrane of pressure sensor for low pressure applications", BIOMEDICAL ENGINEERING AND SCIENCES (IECBES), 2012 IEEE EMBS CONFERENCE ON, IEEE, 17 December 2012 (2012-12-17), pages 601-606, XP032363730, DOI: 10.1109/IECBES.2012.6498031 ISBN: 978-1-4673-1664-4 abstract figures 1,2,3 table II page 601, column 2, line 8 - page 602, column 1, line 12 page 603, column 1, lines 1-23 page 604, column 1, lines 31-33 -----	1-3

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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