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Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
- of inventorship (Rule 4.17(iv))

[Continued on next page]

(54) Title: CAPACITIVE HUMIDITY SENSOR AND METHOD OF FABRICATING THEREOF

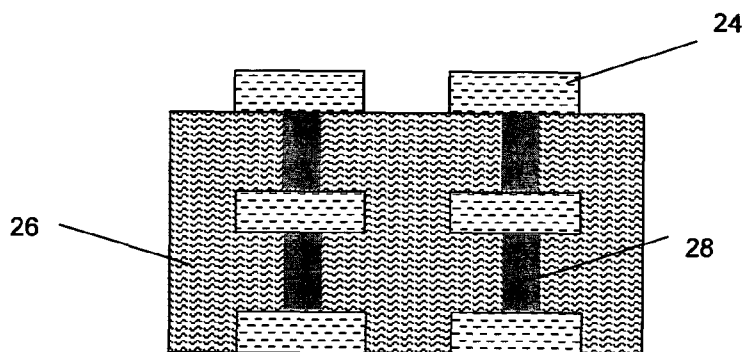


Fig. 9

(57) Abstract: A novel humidity sensor is described. The capacitive humidity sensor comprises at least two pairs of electrode contact pads (24) spaced apart; and a moisture sensitive film (26) formed around the electrode contact pads. The sensor is characterized in that, at least a pair of metals (28) connect the electrode contact pads to form a pair of I-shaped electrodes of a capacitor, wherein the capacitance measured changes according to humidity. Another sensor embodiment can be formed with contact pads exposed at two side of the moisture sensitive film. A method of fabricating the sensor is also described.



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CAPACITIVE HUMIDITY SENSOR AND METHOD OF FABRICATING THEREOF

The present invention relates generally to humidity sensors, more particularly to capacitive humidity sensor.

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BACKGROUND

Conventional capacitive humidity sensor consists of substrate, insulator layer, interdigitated fingers and contact pad. Polyimide is optionally used as moisture
10 sensitive film. The contact pad should be in contact with humidity area to be measured.

The packaging for sensor area interdigitated area must be exposed. However, wire bonds must be protected by resin. Resin can flow to the sensing part and influence
15 the measurement. So the contact pads must be placed within a safe distance from fingers that are far from sensing membrane. The size of sensor is increased to maintain the distance between contact pad and sensing membrane.

US patent 6,580,600 is an example of humidity sensor, particularly a capacitive type
20 humidity sensor. The capacitance type humidity detecting sensor has two electrodes opposing each other with a gap interposed between to form a capacitor on a silicon substrate with a silicon oxide film formed on a surface. A moisture sensitive film is formed so as to cover the two electrodes with a silicon nitride film interposed between. The silicon nitride film protects the two electrodes from moisture passing
25 through the moisture sensitive film. The capacitance formed between the two electrodes changes in accordance with ambient humidity. A switched capacitor circuit formed in a circuit element portion processes a signal indicative of a change in the capacitance formed between the two electrodes.

There are many designs of humidity sensors, but most of the humidity sensors are
30 complex and bulky. Prior art humidity sensor substrate is built on rigid and solid sensor platform, thus limiting the application in term of flexibility application on miniature and vital area measurement. Prior art humidity sensor design based on side by side or horizontal position of contact pad formation with the sensing area thus produce bulky sensor. Sensor size become saturated and cannot be miniaturize for
35 further development.

It is an object of the invention to provide a thin layer humidity sensor so that the size of the sensor can be further reduced.

SUMMARY OF INVENTION

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The proposed structure provides a novel humidity sensor wherein the electrode contact pad is located at the bottom of sensing membrane. A thin layer of flexible humidity sensor can thus be produced.

10

This invention proposes all electrode contact pads to be formed at the midplane of the sensing area, with vertical contact pad formation, therefore reducing the whole size of the sensor. Moisture sensitive films are formed around the electrode contact pads. By forming a novel double sided and folded structure, the thin layer humidity sensor sensing area is maximized and sensor size is reduced. Consequently, the new design will expand the sensor limitation.

15

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be described in greater detail, by way of an example, with reference to the accompanying drawings, in which:

20 Fig. 1 shows a diagram of contact pads formed above silicon and oxide;

Fig. 2 shows a diagram of polyimide being patterned to cover contact pads;

Fig. 3 shows a diagram of metal being patterned above contact pads;

25

Fig. 4 shows a diagram of a second layer of contact pads patterned above metal;

Fig. 5 shows a diagram of another layer of polyimide being patterned to cover contact pads;

30

Fig. 6 shows a diagram of a third layer of contact pads patterned above metal;

Fig. 7 shows a diagram of humidity sensor being connected;

35 Fig. 8 shows an embodiment of humidity sensor; and

Fig. 9 shows another embodiment of humidity sensor.

DESCRIPTION OF EMBODIMENTS

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A method to fabricate humidity sensor will now be described. Silicon is prepared as substrate (20). A layer of oxide (22) is deposited on the silicon. Then, a layer of metal, selected from a material from a group consisting of platinum and aluminum, is selectively patterned and deposited on the oxide to form a pair of electrode contact pads (24) spaced apart, as shown in Fig. 1. A pair of contact pad is used as a basis as a capacitor.

Then, a first moisture sensitive film (26), particularly polyimide layer is coated and patterned around contact pads, as shown in Fig. 2. Polyimide layer acts as the sensing membrane. Then, a layer of metal (28) is deposited and patterned on top of contact pad, as shown in Fig. 3. Next, a second layer of contact pad (24) is deposited and patterned on top of the second layer of metal, as shown in Fig. 4. A layer of polyimide (26) is then coated and cured, as shown in Fig. 5. The first and second polyimide layer is coated to protect humidity sensor with CMOS device in between that two polyimide layer. Moving towards matured technology, fabricated humidity sensor using CMOS standard micro-fabrication surface micromachining offers tremendous and extreme miniaturization of the sensor devices as well as performance and sensitivity. The process was developed to be fully compatible with standard CMOS-IC processes.

25

The process can be optionally repeated to create another layer of metal (28) and contact pad (28), as shown in Fig. 6. The reason for creating another layer of contact pad for double sided contact pad area as design with double sided sensing area.

30 Connection between sensor and other devices (30) can be formed, as shown in Fig. 7, to other module such as micro-sensor device or CMOS circuit, thus integration of CMOS and micro-sensor in the same platform can be produced.

Monolithic integration with integrated circuit or conditioning circuit can be formed with parallel fabrication process. The proposed on chip integration connection is formed during fabrication process for miniaturizations and integrated sensor system.

35

The silicon and oxide layer is then removed with hydrofluoric acid. This etchant is CMOS compatible material as it used for thin layer oxide etch. It releases the sensor from the substrate. Now, a basic humidity sensor having a single contact pad area is formed, as shown in Fig. 8. Notice that a pair of I-shaped electrodes of a capacitor is formed, wherein the capacitance measured changes according to humidity. A double sided contact pad area sensor, after etched is shown in Fig. 9. The contact pads (24) are exposed at two sides of the polyimide film (26).

The contact pad, having metallic fingers, sandwiched with polyimide layers are capacitive to function as humidity sensors for measuring humidity as well as moisture. Polyimide layers act as dielectric material between capacitive contact pads. Polyimide also absorbs water molecule, which changes the permittivity between contact pads. The unique arrangements between combinations of polyimide layer within each porous insulating layer are claimed as the invention. Increased sensitivity of capacitance is achieved due to thicker permittivity of dielectric to absorption water molecule. Multi-layer electrodes are used for deeper and wider penetration area of water vapor absorption of the sensor, in order to increase the total capacitance and sensor sensitivity. For this novel design invention, the same sensor could now be used to measure water vapor and soil water.

The contact pads can be made to be symmetrical with the second polyimide layer and third contact pad layer, as shown in Fig. 9. Hence, it can be attached to package at either side.

Folded structure allows flexible attachment of double sided sensing area application; front or back side have same properties and performances as humidity layer sensor. The selection of sensing area to face depends on user choice.

Accordingly, the invention disclosed a humidity sensor. It is the combination of the above features and its technical advantages give rise to the uniqueness of such invention. Although the descriptions above contain much specificity, these should not be construed as limiting the scope of the embodiment but as merely providing illustrations of some of the presently preferred embodiments.

CLAIMS

1. A capacitive humidity sensor, comprising:
at least two pairs of electrode contact pads (24) spaced apart;
5 a moisture sensitive film (26) formed around the electrode contact pads;
characterized in that,
at least a pair of metals (28) connect the electrode contact pads to form a pair of
I-shaped electrodes of a capacitor, wherein the capacitance measured changes
according to humidity.
10
2. A sensor according to claim 1, wherein layers of electrode contact pads (24) are
formed and exposed at two sides of the moisture sensitive film (26).
3. A sensor according to claim 1, wherein the moisture sensitive film (26) is
15 polyimide.
4. A sensor according to claim 1, wherein the electrode contact pads (24) are
formed from a material selected from a group consisting of aluminum and
platinum.
20
5. A method of fabricating humidity sensor, comprising:
depositing a layer of oxide (22) on substrate (20);
selectively depositing a pair of contact pads (24) spaced apart on oxide (22);
coating and patterning a first moisture sensitive layer (26);
25 depositing and patterning a layer of metal (28) on top of contact pads (24);
depositing and patterning a second pair of contact pads (24) spaced apart on
top of metal (28);
coating and curing a second layer of moisture sensitive layer (26);
characterized in that,
30 removing silicon and oxide layer to expose contact pad that acts as contact
area for sensing humidity.
6. A method according to claim 5, further comprising adding a layer of metal (28) on
top of contact pads (24), and depositing and patterning a third pair of contact
35 pads spaced apart on top of metal (28), said contact pads are exposed on the
other side of the moisture sensitive layer.

7. A method according to claim 5 or 6, wherein the moisture sensitive film (26) is polyimide.
8. A sensor according to claim 5, wherein the electrode contact pads (24) are
5 formed from a material selected from a group consisting of aluminum and platinum.

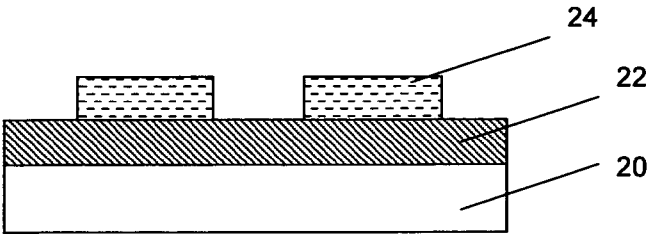


Fig. 1

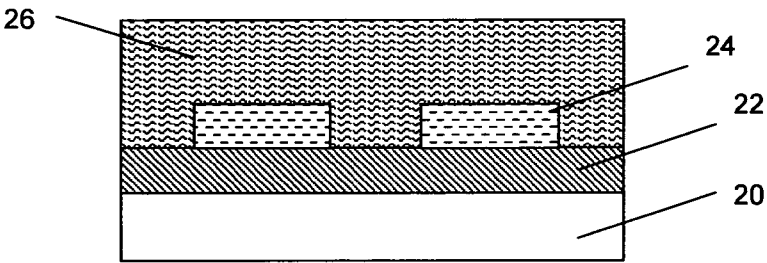


Fig. 2

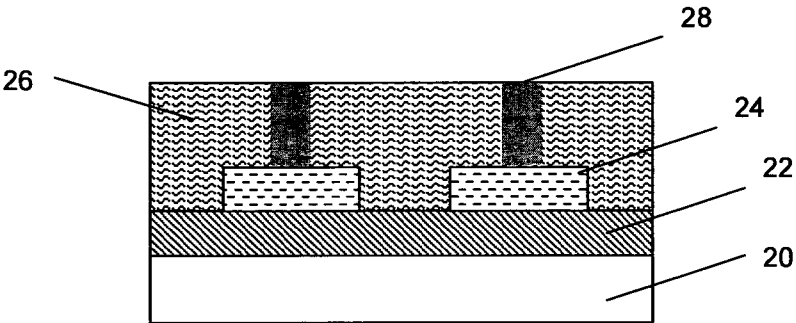


Fig. 3

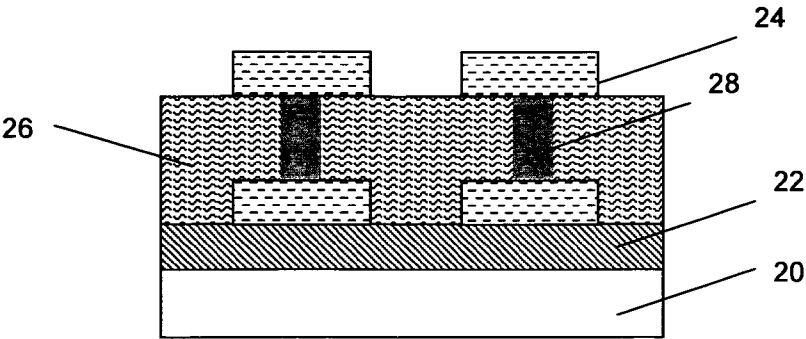


Fig. 4

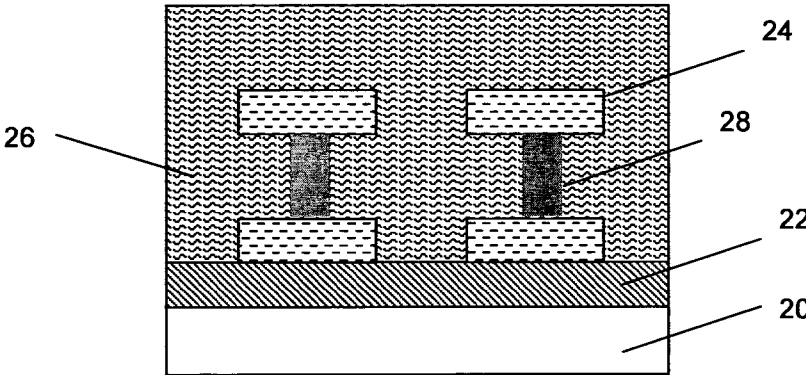


Fig. 5

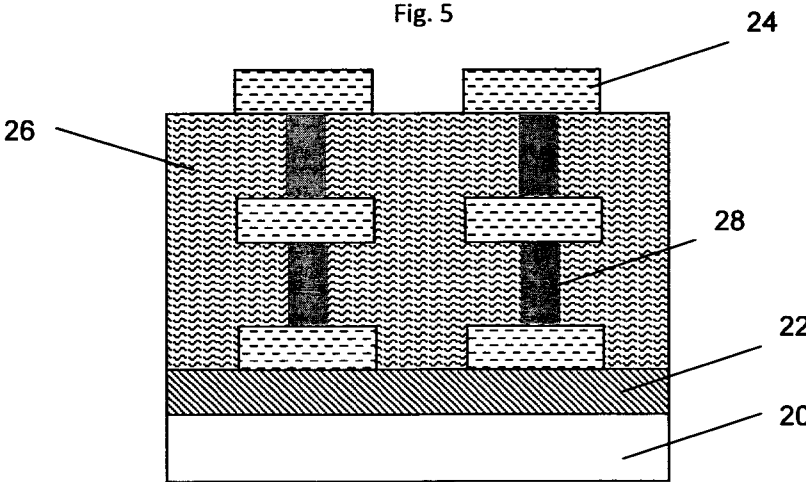


Fig. 6

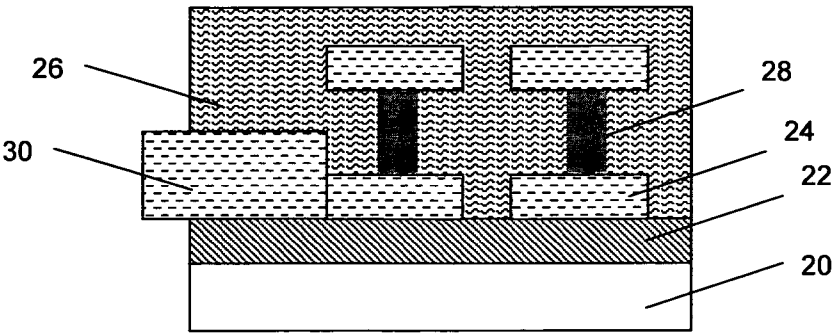


Fig. 7

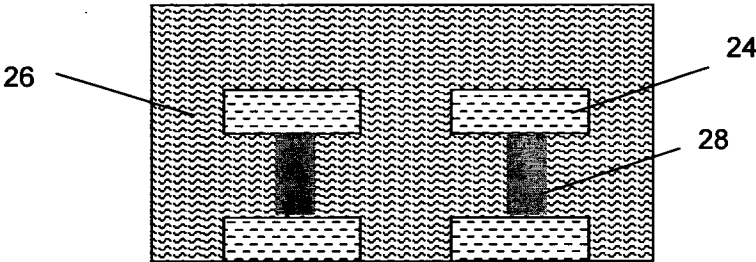


Fig. 8

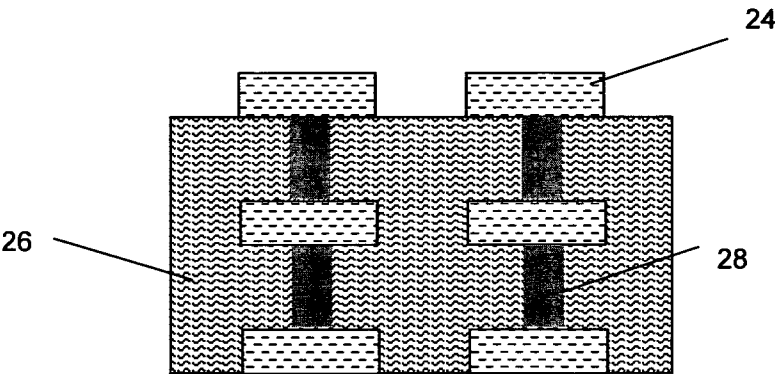


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER												
Int. Cl.												
G01N 27/22 (2006.01) F25D 21/02 (2006.01) H01G 7/00 (2006.01)												
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)												
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) EPODOC, WPI, Google - capacitive humidity moisture vapour sensor instrument device measure monitor electrode plate profile perpendicular orthogonal i-shaped t-shaped hygrometer												
C. DOCUMENTS CONSIDERED TO BE RELEVANT												
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.										
A	US 7812424 B2 (BARTH et al.) 12 October 2010 Fig 1c											
A	KR 10-0951546 B1 (KIM et al.) 25 June 2008 See abstract, machine translation from http://kposd.kipo.go.kr:8088/up/kpion/											
A	WO 2010/056049 A2 (HONG et al.) 20 May 2010 See abstract											
☐ Further documents are listed in the continuation of Box C ☒ See patent family annex												
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"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family											
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Date of the actual completion of the international search 08 August 2011		Date of mailing of the international search report 18.08.2011										
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaaustralia.gov.au Facsimile No. +61 2 6283 7999		Authorized officer Simon Gilmore AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : +61 2 6283 2191										

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/MY2011/000036

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
US	7812424	DE	102008059871	US	2009160020	US	2010330771
KR	20080058286	NONE					
WO	2010056049	KR	20100053082				
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.							
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