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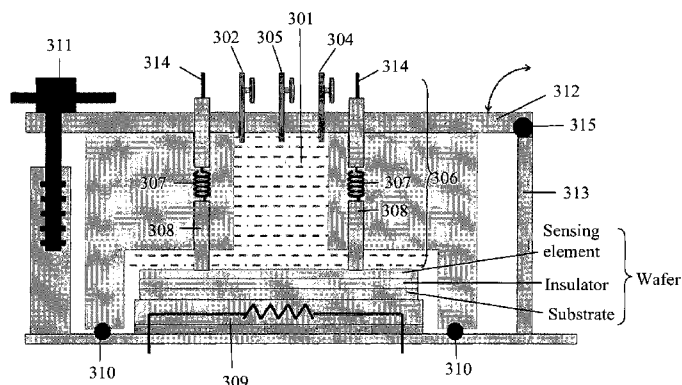
Declarations under Rule 4.17:

- 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))
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(54) Title: APPARATUS AND METHOD FOR ELECTRICALLY TESTING A GAS SENSING ELEMENT



(57) Abstract: Apparatus for characterizing a sensing element which comprises of at least one gas chamber (301), at least one gas connection means, at least two electrical connection means (306), at least one heater (309), at least one sealing means (310) and at least one locking means. The characterization process of said sensing element can be carried out at wafer level through resistance measurement, whereby said sensing element can be a blanket sensing element before proceed to fabricating of full sensor device. The connection means comprises at least one spring in connection with an electrode for improved contacting of the workpiece.

APPARATUS AND METHOD FOR ELECTRICALLY TESTING A GAS SENSING ELEMENT

1. TECHNICAL FIELD OF THE INVENTION

The present invention relates generally to an apparatus for
5 characterizing sensing element which comprises of at least one gas chamber, at
least one gas connection means, at least two electrical connection means, at least
one heater, at least one sealing means and at least one locking means. The
characterization process of said sensing element can be carried out at wafer
level through resistance measurement, whereby said sensing element can be a
10 blanket sensing element before proceed to fabricating of full sensor device.

2. BACKGROUND OF THE INVENTION

Gas sensors or detection instruments are widely used in many industrial,
medical and commercial applications such as industrial health and safety,
environmental monitoring, manufacture process monitoring, petrochemical
15 refining, semiconductor processing and biomedical applications. Gas sensor
especially electronic noses were originally used for quality control applications in
the food and cosmetics industries. Aroma and taste of foods are due to the
interaction of human sensory organs with the volatile and semi-volatile organic

chemical constitutes in food materials. Some food may contain dozens or hundreds of these volatiles flavor contributing chemicals which can be analyzed using GC/MS (gas chromatography/mass spectrometry analysis). Unlike chromatography techniques, the electronic nose does not attempt to separate or
5 resolve all individual volatile components. It uses an array of sensors that responds to each volatile chemical much like the human nose functions.

The metal oxide-based thin-film gas sensors are typically require elevated temperatures range from 200 °C to 400 °C to detect gas species. The microhotplate is usually a perfect platform for such devices because of its small
10 size and ease of fabrication using standard commercial CMOS technology. The microhotplate is a suspended structure fabricated with micromachining technology which contains a heating element. For example, the microhotplate can be fabricated using a standard commercial CMOS process and can use a polysilicon layer for a resistor-heating element. As silicon is a good heat
15 conductor, it must be removed from underneath the microhotplate to achieve high thermal efficiency. FIG. 1 shows the cross-section view of the gas sensor whereby microhotplate is suspended in a cavity of the substrate material.

In order to utilize the microhotplate, the sensor needs to go for full process flow and after that need to be sent for packaging. FIG. 2-A shows the flowchart
20 on the conventional process from the production of gas sensor to characterization. Generally the gas sensor process would require a few weeks for

completion. This involves several steps such as wafer saw, die attached, wire bond and encapsulation before proceed to sensing element test. Furthermore, gas sensor sensing element optimization requires to do experiment on various process recipes and process parameter on the sensing element. The current
5 development will be time consuming and costly if full process flow is carried out and therefore it will take some time for full process flow and packaging to complete in order to utilize the microhotplate.

It would hence be extremely advantageous if the above shortcoming is alleviated by having an apparatus for characterizing sensing element whereby
10 the characterization process of said sensing element can be carried out at wafer level by using of blanket sensing element before proceed to fabricating of full sensor device, as shown in FIG 2-B. The present invention is using blanket sensing element without patterning and external heat source is employed to heat the sensing element for characterization. With this solution, it will speed up the
15 sensing element characterization process and therefore saving the processing cost.

3. SUMMARY OF THE INVENTION

Accordingly, it is the primary aim of the present invention to provide a method and apparatus for characterizing sensing element wherein the
20 characterization process of said sensing element can be carried out at wafer level.

It is another object of the present invention to provide a method and apparatus for characterizing sensing element wherein blanket sensing element is used for characterization before proceed to fabricating of full sensor device.

Yet another object of the present invention is to provide a method and
5 apparatus for characterizing sensing element which is able to reduce process flow from producing of gas sensor to characterization.

Yet another object of the present invention is to provide a method and apparatus for characterizing sensing element which is able to speed up the sensing element characterization process and saving processing cost.

10 Other and further objects of the invention will become apparent with an understanding of the following detailed description of the invention or upon employment of the invention in practice.

According to a preferred embodiment of the present invention there is provided,

15 An apparatus for characterizing sensing element comprising:

at least one gas chamber;

at least two gas connection means which comprises of gas inlet and means for venting;

at least two electrical connection means;

characterized in that

said apparatus further comprising of at least one heater to heat said sensing element at wafer level for characterization through resistance measurement, wherein said sensing element is a blanket sensing element before proceed to fabricating of full sensor device;

a temperature controlling mechanism is provided at said heater (309) to control the temperature at the desired level throughout the characterization process;

said means for venting (304) is used to vent said gas chamber (301) to the desired pressure before electrical measurement is carried out as well as to discharge the gases contained in said gas chamber (301) at the end of the characterization process;

said electrical connection means (306) comprises of at least one spring (307) and at least one electrode (308) wherein said spring (307) is in connection with said electrode (308);

said gas chamber (301) is made of material but not limited to glass, polytetrafluoroethylene (PTFE) or metal.

In another aspect there is provided,

A methodology for characterizing sensing element comprising steps of:

- i. placing wafer or sensing element to be tested onto heater;
- ii. heating said sensing element through said heater to a
5 predetermined temperature;
- iii. conducting electrical measurement to said sensing element
using electrical connection means;

characterized in that

said methodology is carried out at wafer level, wherein said sensing
10 element is a blanket sensing element before proceed to fabricating of full
sensor device;

said methodology for characterizing sensing element is carried out at
room temperature by positioning said wafer or sensing element onto said
heater (309) when said heater (309) is not activated;

15 said electrical measurement is resistance measurement based on
adsorption of gas species contained in said gas chamber (301) onto the

surface of the metal-oxide layer of said sensing element to produce a substantial change in its electrical resistance.

4. BRIEF DESCRIPTION OF THE DRAWINGS

Other aspect of the present invention and their advantages will be discerned after studying the Detailed Description in conjunction with the accompanying drawings in which:

FIG. 1 is a cross-section view of the gas sensor whereby microhotplate is suspended in a cavity of the substrate material.

FIG. 2-A is a flowchart on the conventional process from the production of gas sensor to characterization.

FIG. 2-B is a flowchart on the present invention from the production of gas sensor to characterization.

FIG. 3 is a cross sectional view of apparatus for characterizing sensing element at wafer level of the present invention.

FIG. 4-A is a cross sectional view of top portion of the apparatus for characterizing sensing element of the present invention.

FIG. 4-B is a cross sectional view of bottom portion of the apparatus for characterizing sensing element of the present invention.

FIG. 5 is a cross sectional view of a sensing element or wafer.

FIG. 6 is a flow chart on sensing element characterization process using the apparatus of the present invention.

5. DETAILED DESCRIPTION OF THE DRAWINGS

5 In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those of ordinary skill in the art that the invention may be practised without these specific details. In other instances, well known methods, procedures and/or components have not been described in detail so as not to
10 obscure the invention.

The invention will be more clearly understood from the following description of the embodiments thereof, given by way of example only with reference to the accompanying drawings which are not drawn to scale.

Referring to FIG. 3, there is shown a cross sectional view of apparatus for
15 characterizing sensing element at wafer level. The said apparatus (100) comprises of at least one gas chamber (301), at least one gas connection means, at least two electrical connection means (306), at least one heater (309), at least one sealing means (310) and at least one locking means (311). The components in said

apparatus for characterizing sensing element are typically divided to two portions, which are the top portion and the bottom portion.

Referring now to FIG. 4-A, there is shown a cross sectional view of top portion of said apparatus for characterizing sensing element. Said top portion of said apparatus comprises of at least one gas connection means, at least two electrical connection means (306), a lid portion (312) and at least one locking means (311). Said locking means (311) is positioned at one end of said lid portion (312) while a hinge (315) is provided at the other end of said lid portion (312) to connect said lid portion (312) with the frame support structure (313) of said apparatus of the present invention. Said top portion is a movable portion whereby it can be opened and closed through the end of said lid portion with locking means. FIG. 4-B shows a cross section view of bottom portion of said apparatus for characterizing sensing element. Said bottom portion of said apparatus comprises of at least one heater (309) as well as the base portion.

In said gas chamber (301) contain a test gas which includes but not limited to carbon dioxide, nitrogen, helium, acetylene or a dilution thereof. Said gas chamber (301) is the place where the adsorption of gas species onto the surface of a metal-oxide semiconductor occur. Said gas chamber (301) can be made of material but not limited to glass, polytetrafluoroethylene (PTFE) or metal. Alternatively a plurality of gas chamber can be provided in said apparatus depending on the application. Said gas connection means comprises of gas inlet

(302), means for venting (304) and means for vacuuming (305). Typically, before said gas chamber (301) is filled with gas through gas inlet (302), said gas chamber (301) shall be in vacuum conditions by switching on said means for vacuuming (305) to remove the unwanted impurities or unwanted gas which may be
5 contained in said gas chamber (301). Said means for venting (304) is used to vent said gas chamber (301) in order to achieve the desired pressure, for example the pressure at the range of 1 to 10 bars in said gas chamber (301). While at the end of the characterization process, all the gases contained in said gas chamber (301) will be discharged through said means for venting (304). Said electrical
10 connection means (306) comprises of at least one electrical connector (314), at least one spring (307) and at least one electrode (308) whereby said spring (307) is in connection with said electrode (308) to the wafer for characterization. Alternatively said spring (307) can also be located at the other end of said electrode (308) which is in contact with the wafer to be tested. Said spring (307)
15 can also be located at both end of said electrode (308) in said electrical connection. Said use of spring (307) can be replaced with other mechanism such as using of flexible probe as long as said sensing element to be tested is prevented from being damaged during the process of characterization. Preferably at least a pair of electrodes (308) is connected to the sensing element in
20 order for characterization process to be carried in said apparatus of the present invention. Said characterization of sensing element includes electrical measurement for sensing element resistance test. At least one heater (309) with

heating element or any other heating source is provided to heat said wafer and consequently heating the sensing element. Said heater (309) to be used can be a hot chuck which is able to heat said wafer to a certain desired temperature which is in the range of 200 °C - 500 °C. A temperature controlling mechanism is also
5 provided at said heater (309) to control the temperature at the desired level throughout the characterization process. Said heater (309) is also function as wafer holder with a clamp or vacuum chuck to hold the wafer in place. The integration of the heating element to the wafer holder would allow direct heating of said wafer or sensing element for characterization. Alternatively, if the
10 characterization process is to be carried out at room temperature, said wafer or sensing element can be positioned onto said heater (309) without activating said heater (309). Said sealing means (310) can be but not limited to an o-ring or metal flange gasket which is used to prevent gas leakage during the characterization process. Typically at least one sealing means (310) is positioned at the base
15 portion of said apparatus to prevent the gas leakage. Said locking means (311) is employing screw-typed locking mechanism gas chamber enclosure that can be opened and closed. In addition, an insulation material such as non conductive polymer is used beneath said heater (309) of the present invention in order to prevent heat from conducting through the apparatus body.

20 Referring now to FIG. 5, there is shown a cross sectional view of a sensing element or wafer whereby a blanket metal oxide thin film or other type of

sensing element is being deposited on the surface of insulator. Said insulator is deposited on the surface of substrate and is made of silicon oxide or any other material than can act as insulator. Said substrate can be made of material such as silicon wafer, glass or the like. After said standalone sensing element or wafer is produced, characterization of said sensing element by having resistance test can be carried out before said sensing element is proceed to package level or fabricating of full sensor device. Thus by having the apparatus for characterizing sensing element of the present invention, early detection of any defective units is viable as the characterization process can be carried out at wafer level. Hence this would ultimately reduce the sensing element characterization time as well as the processing cost.

Referring now to FIG. 6, there is shown a flow chart on sensing element characterization process using said apparatus of the present invention. The characterization process begins by first having the sensing element or wafer to be tested being positioned on said heater (309). The lid portion (312) of said apparatus is then closed, followed by tightening said locking means (311) for airtight. Said gas chamber (301) shall be in vacuum conditions to remove the unwanted impurities. This is to make sure that there is not impurities present in said gas chamber (301) before flowing the gas such as carbon dioxide, nitrogen, helium, acetylene or a dilution thereof through gas inlet (302) into said chamber (301). The occurrence of the impurities in said gas chamber (301) would affect the

accuracy of result obtained during sensing element resistance test. After that, the desired pressure condition, for example the pressure at the range of 1 to 10 bars in said gas chamber (301) can be achieved through adjusting said means for venting (304). When the desired pressure is obtained, said temperature
5 controlling mechanism is activated to heat said sensing element through said heater (309) to the desired or predetermined temperature, for example in the range of 200 °C - 500 °C. The electrical measurement or resistance measurement of the sensing element can be carried out when the desired temperature is obtained. The occurrence is based on the adsorption of the gas species contained
10 in said gas chamber (301) onto the surface of said metal-oxide layer of said sensing element to produce a substantial change in its electrical resistance. This change in resistance results from the loss or gain of surface electrons as a result of adsorbed oxygen reacting with other types of gas molecules. The changes in resistance is then measured by using of said at least two electrical connection
15 means (306) to said pair of electrodes (308). Then the result obtained from the characterization process is analysed to determine the quality of said sensing element before being proceed to package level.

While the preferred embodiment of the present invention and its advantages has been disclosed in the above Detailed Description, the invention
20 is not limited thereto but only by the scope of the appended claim.

WHAT IS CLAIMED IS:

1. An apparatus for characterizing sensing element comprising:

at least one gas chamber (301);

at least two gas connection means which comprises of gas inlet
5 (302) and means for venting (304);

at least two electrical connection means (306);

characterized in that

said apparatus further comprising of at least one heater (309) to
heat said sensing element at wafer level for characterization
10 through resistance measurement, wherein said sensing element is a
blanket sensing element before proceed to fabricating of full sensor
device;

a temperature controlling mechanism is provided at said heater
(309) to control the temperature at the desired level throughout the
15 characterization process;

said means for venting (304) is used to vent said gas chamber (301)
to the desired pressure before electrical measurement is carried out

as well as to discharge the gases contained in said gas chamber (301) at the end of the characterization process;

said electrical connection means (306) comprises of at least one spring (307) and at least one electrode (308) wherein said spring (307) is in connection with said electrode (308);

said gas chamber (301) is made of material but not limited to glass, polytetrafluoroethylene (PTFE) or metal.

2. An apparatus for characterizing sensing element as claimed in Claim 1 wherein said gas connection means further comprising of means for vacuuming (305) to vacuum said gas chamber (301) in order to remove impurities contained in said gas chamber (301).
3. An apparatus for characterizing sensing element as claimed in Claim 1 wherein said use of spring (307) alternatively is replaced with other mechanism such as using of flexible probe as long as said sensing element to be tested is prevented from being damaged during the characterization process.
4. An apparatus for characterizing sensing element as claimed in Claim 1 wherein said heater (309) is a hot chuck to heat said wafer

to a certain desired temperature which is in the range of 200 °C – 500 °C.

5. An apparatus for characterizing sensing element as claimed in Claim 1 wherein said heater (309) is also function as a wafer holder with a clamp or vacuum chuck to hold the wafer in place and is integrated with heating element at said heater (309).

6. An apparatus for characterizing sensing element as claimed in Claim 1 wherein said apparatus further comprising of sealing means (310) to prevent gas leakage during the characterization process; wherein said sealing means (310) is but not limited to an o-ring or metal flange gasket.

7. An apparatus for characterizing sensing element as claimed in Claim 1 wherein said apparatus further comprising of locking means (311) which is positioned at one end of lid portion (312) to open or close said gas chamber (301); wherein said locking means (311) is but not limited to screw-typed locking mechanism for gas chamber enclosure.

8. An apparatus for characterizing sensing element as claimed in Claim 1 wherein an insulation material is used beneath said heater

(309) to prevent heat from conducting through said apparatus body.

9. A methodology for characterizing sensing element comprising steps of:

5 i. placing wafer or sensing element to be tested onto heater (309);

ii. heating said sensing element through said heater (309) to a predetermined temperature;

10 iii. conducting electrical measurement to said sensing element by using electrical connection means (306);

characterized in that

said methodology is carried out at wafer level, wherein said sensing element is a blanket sensing element before proceed to fabricating of full sensor device;

15 said methodology for characterizing sensing element is carried out at room temperature by positioning said wafer or sensing element onto said heater (309) when said heater (309) is not activated;

said electrical measurement is resistance measurement based on adsorption of gas species contained in said gas chamber (301) onto the surface of the metal-oxide layer of said sensing element to produce a substantial change in its electrical resistance.

- 5 10. A methodology for characterizing sensing element as claimed in Claim 9 wherein after said step of placing sensing element to be tested onto heater (309), further comprising of the following steps before step of heating said sensing element through said heater (309):
- 10 a. closing the lid portion (312) of the apparatus for characterizing sensing element;
- b. tightening locking means (311) for airtight;
- c. vacuuming gas chamber (301) to remove impurities;
- d. filling gas into said gas chamber (301) through gas inlet (302);
- 15 e. venting said gas chamber (301) to desired pressure through means for venting (304).

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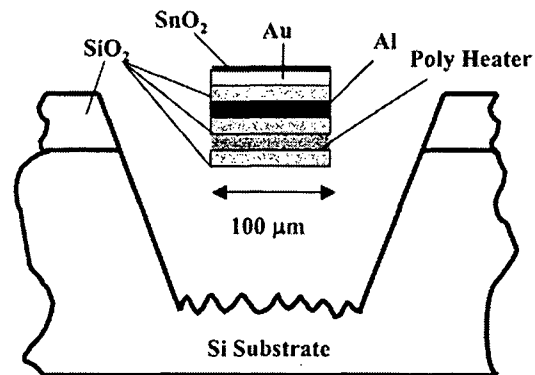


FIG. 1

•Gas sensor process to characterization flow – package level

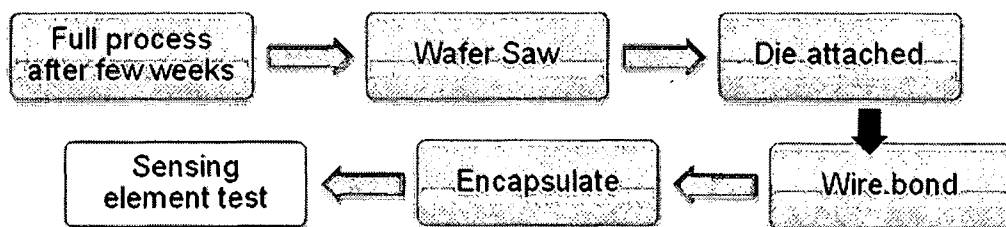


FIG. 2-A

•Sensing element process to characterization flow- wafer level



FIG. 2-B

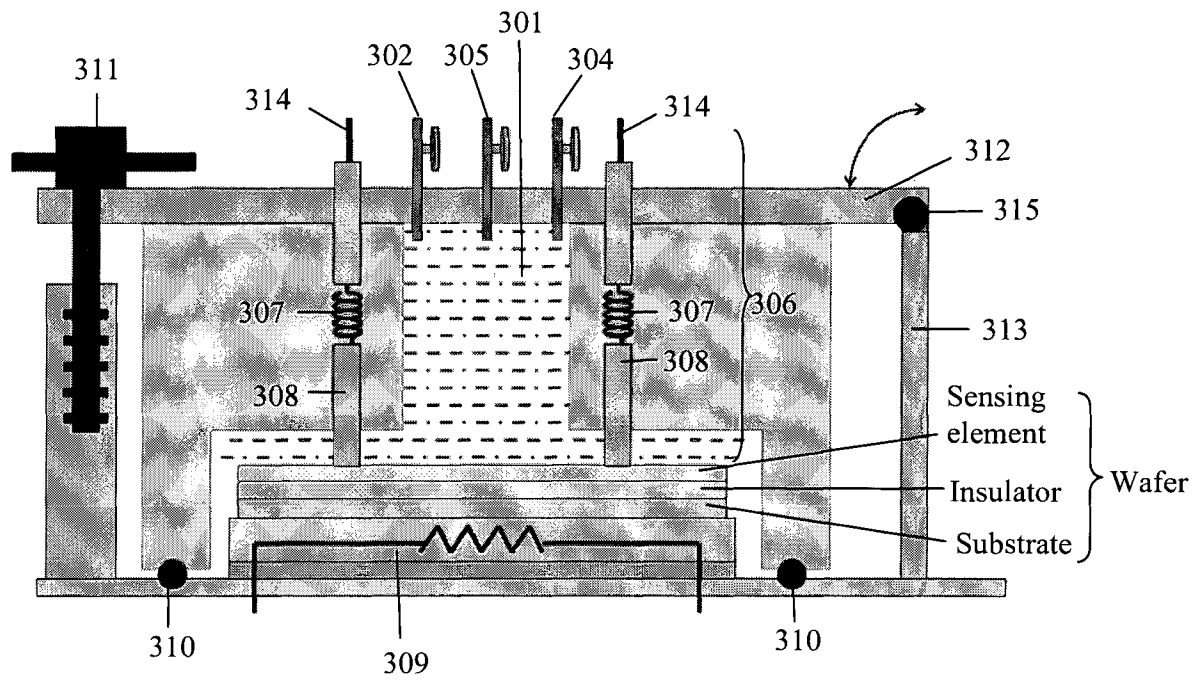


FIG. 3

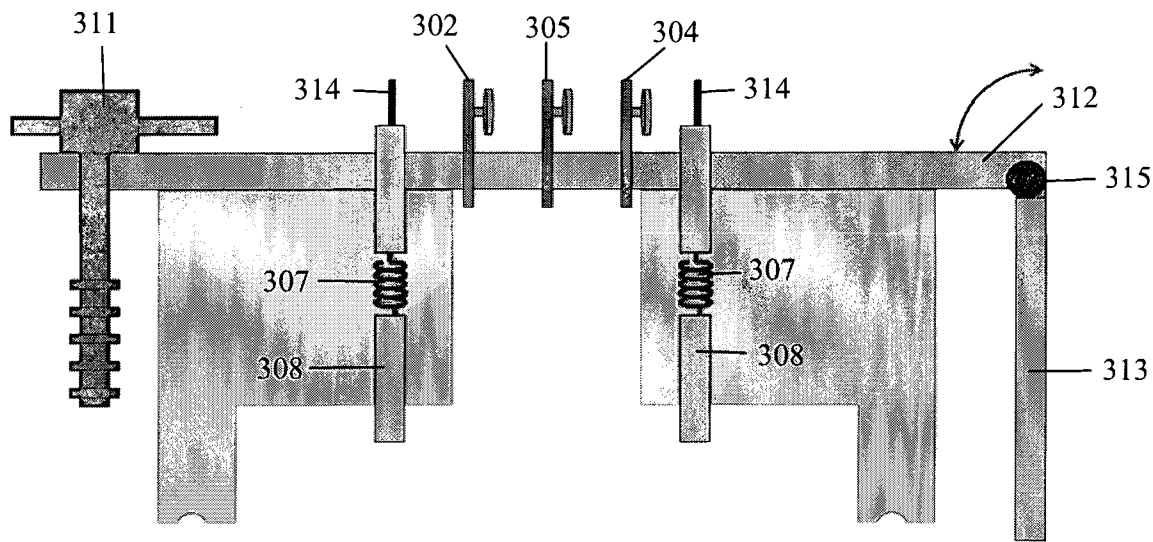


FIG. 4-A

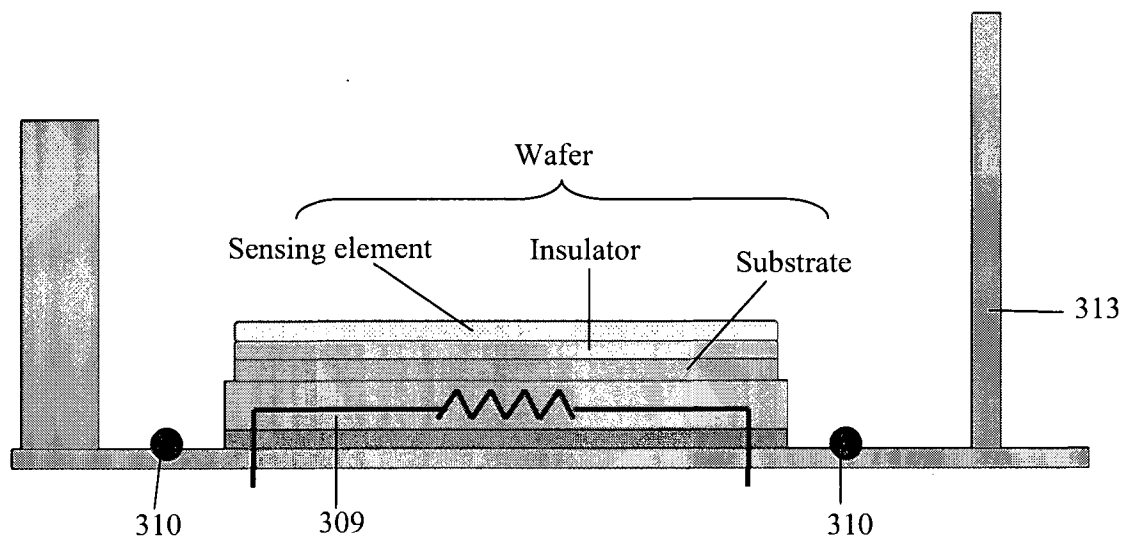


FIG. 4-B

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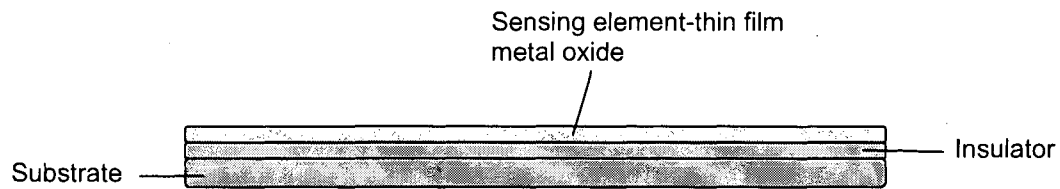


FIG. 5

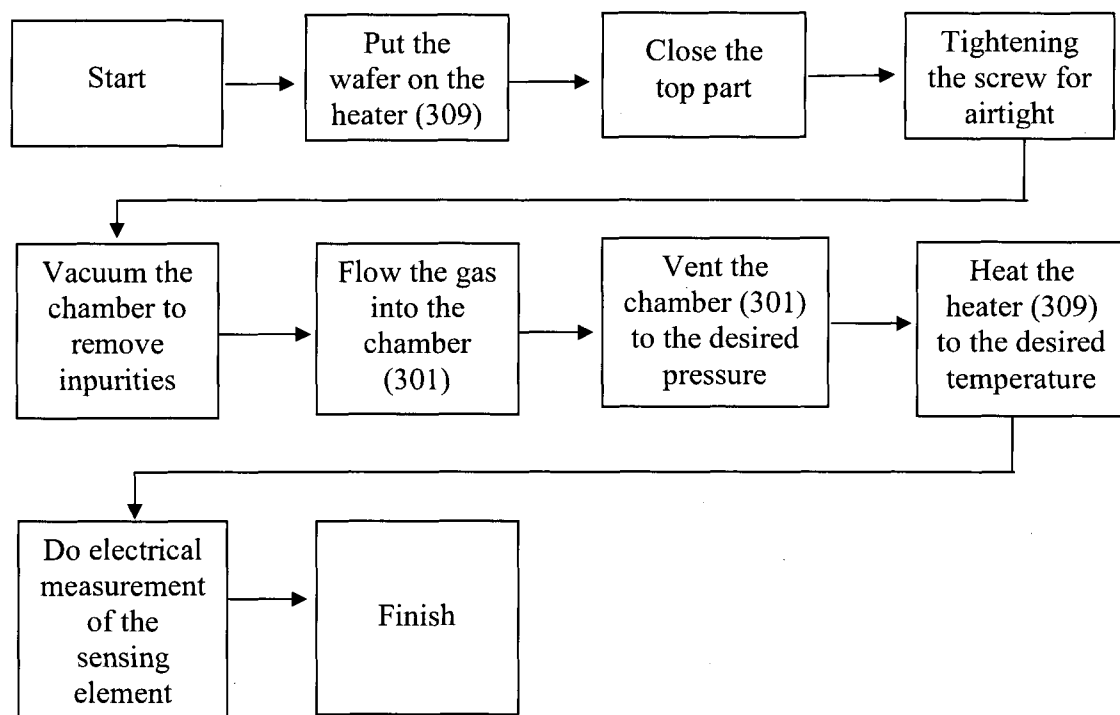


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/MY2012/000194

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N27/20
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)
G01N H01L

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	CN 201 754 174 U (BYD CO LTD) 2 March 2011 (2011-03-02)	9,10
Y	figure 1 paragraphs [0011] - [0022] -----	1-8
Y	US 5 477 157 A (LEE YOUN [US]) 19 December 1995 (1995-12-19) column 4, lines 46-52; figure 1 -----	1-8
Y	EP 1 139 099 A2 (SIEMENS AG [DE]) 4 October 2001 (2001-10-04) paragraph [0018]; figure 1 -----	1-8
Y	EP 1 677 101 A1 (TDK CORP [JP]) 5 July 2006 (2006-07-05) paragraph [0009]; figure 2 -----	1-8



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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05/11/2012

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 201754174	U	02-03-2011	NONE
US 5477157	A	19-12-1995	NONE
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