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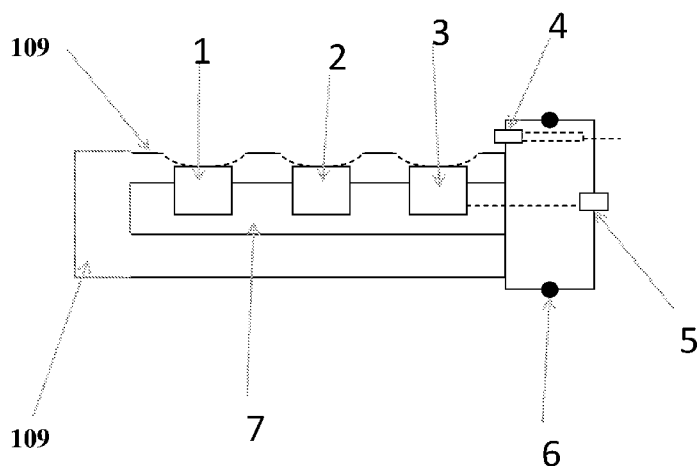
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- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

[Continued on next page]

(54) **Title:** AN AQUATIC POLLUTANT SENSOR



(57) **Abstract:** The present invention relates to an aquatic pollutant sensor comprising: a transducer (101) as sensing electrode to convert analyte concentrations to voltage signals; an ion selective layer (103) deposited on the transducer (101) to selectively transport target analyte to the said transducer (101); potentiometry readout circuit (105) to measure potential difference between chemical sensor and reference electrode; an inert sensor tip substrate (107) having at least one sensor opening, at least one reference electrode opening and at least two tracks for wire traces; a protector (109) to provide mechanical strength, reduce fouling and allow cleaning; and a reference electrode (111); characterized in that the transducer (101) further comprising an electrochemical transducer nanocomposite; the reference electrode (111) is in the form of solid; and the protector (109) further comprising an inert porous protective encapsulation.

Figure 1



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- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
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- *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

Description

Title of Invention: AN AQUATIC POLLUTANT SENSOR

[1] **FIELD OF INVENTION**

[2] The present invention relates to a continuous aquatic pollutant sensor.

[3] **BACKGROUND OF THE INVENTION**

[4] Pollutant/chemical sensors such as ion selective electrode (ISE) or ion sensitive field effect transistor (ISFET) typically use plasticized lipophilic sensing membrane to achieve selectivity for the target analyte. Upon long exposure in aqueous media the plasticizer molecules leach out and the sensing membrane becomes too hard. Moreover, the membrane adhesion to electrode becomes weaker and the membrane could delaminate. Both reasons result in functional failure of the sensors. There are many issues encountered in measuring analytes in the field and problems suffered by field deployed chemical sensors, such as conventional pollutant analysis methods use chemical reagents and analytical instruments, available pollutant monitoring sensors integrate large sensor probes, existing chemical sensors use liquid electrolytes in reference electrode, continuous monitoring in polluted environment causes fouling on sensor element/tip, and long exposure to aqueous media causes delamination of polymeric sensing membranes.

[5] One of the examples of water sensor which bearing said problems is EP0651248 which relates to water quality sensor apparatus comprising a substrate on which a plurality of sensors are supported in spaced apart relationship, each sensor being responsive to a different water characteristic and each sensor comprising a sensor region which, in use, is arranged to be contiguous with water the characteristics of which are to be sensed, which sensor regions are electrically connected to connector means via conductors supported on the substrate, the conductors and the connector means being arranged to be non-contiguous with the water in use of the apparatus. Therefore there is a need for a sensor which overcomes such problems.

[6] **SUMMARY OF THE INVENTION**

[7] According to an aspect of the present invention, the present invention provides an aquatic pollutant sensor comprising: a transducer (101) as sensing electrode to convert analyte concentrations to voltage signals; an ion selective layer (103) deposited on the transducer (101) to selectively transport target analyte to the said transducer (101); potentiometry readout circuit (105) to measure potential difference between chemical sensor and reference electrode; an inert sensor tip substrate (107) having at least one sensor opening, at least one reference electrode opening and at least two tracks for wire traces; a protector (109) to provide mechanical strength, reduce fouling and allow cleaning; and a reference electrode (111); characterized in that the

transducer (101) further comprising an electrochemical transducer nanocomposit; the reference electrode (111) is in the form of solid; and the protector (109) further comprising an inert porous protective encapsulation.

- [8] The proposed invention is advantageous for ion selective chemical sensors intended for long term exposure in aqueous media and in situ measurement due the electrochemical transducer nanocomposite (101) ensures that the transduced signals represent accurate detection of analyte at sub-ppm levels, with negligible error due to signal drift or noise. The solid reference electrode (111) does not need liquid electrode and thus maintenance free and suitable for field deployment, and the inert sensor tip substrate (107) and the porous protective encapsulation (109) provide mechanical strength, reduce fouling and allow cleaning.

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

- [10] **Figure 1** illustrates cross section view of the sensor tip substrate (107) of the present invention.

- [11] **Figure 2** illustrates top view of the sensor tip substrate (107) of the present invention.

- [12] **Figure 3** illustrates the electrochemical transducer nanocomposite (101) and the ion selective layer (103) of the present invention.

- [13] **Figure 4** illustrates the solid reference electrode (111) of the present invention.

- [14] **Figure 5** illustrates flowchart of a method for preparing an aquatic pollutant sensing procedure of the present invention.

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

- [16] Generally, the present invention relates to an aquatic pollutant sensor comprising: a transducer (101) as sensing electrode to convert analyte concentrations to voltage signals; an ion selective layer (103) deposited on the transducer (101) to selectively transport target analyte to the said transducer (101); potentiometry readout circuit (105) to measure potential difference between chemical sensor and reference electrode; an inert sensor tip substrate (107) having at least one sensor opening, at least one reference electrode opening and at least two tracks for wire traces; a protector (109) to provide mechanical strength, reduce fouling and allow cleaning; and a reference electrode (111); characterized in that the transducer (101) further comprising an electrochemical transducer nanocomposite; the reference electrode (111) is in the form of solid; and the protector (109) further comprising an inert porous protective encapsulation.

- [17] **Figure 1 and Figure 2** shows the following main features: inert electrode holders (1), (2) are for housing sensing electrodes, inert holder (3) for housing the solid reference electrode (111), a temperature sensor (4) encapsulated with inert materials, wire traces (5), (10) and electrical contact connecting the traces (5), (10) to the readout

circuit (105). A chemical resistant o-ring (6) prevents water or analyte from entering the electronics board. A sensor tip (7) is for securing the sensor/transducer (101) and reference electrode holders (3) on the inert substrate (107) and providing channels for electrical wire tracings from the electrodes to the electrical contact. The inert porous protective encapsulation (109) comprising porous and curved windows on top of the sensor (101) and reference electrode (111) surfaces. The inert porous protective encapsulation (109) further comprising: protective windows having at least flat surface, at least 0.5mm thickness and at least 0.5um pore size, having direct contact with or detached from the sensor tip substrate. The inert porous protective encapsulation (109) having flat or curved surface which is detachable from the sensor tip substrate (107) and having fitting tracks.

[18] **Figure 3** illustrates the electrochemical transducer nanocomposite (101) and the ion selective layer (103) of the present invention which make up the sensing electrode. An inert cup (11), preferably made of Teflon materials, is for holding the compacted solid sensing electrode. A conductive adhesive (16) is to secure the electrode to the inert casing, holding the wire tracing and give adhesion with the compacted electrode. The electrochemical transducer nanocomposite (101) further comprising: 1 to 30 percent graphite; 1 to 5 percent clay nanoparticles; 3 to 30 percent doped polypyrrole nanoparticles; and 0.1 to 5 percent carbon nanotubes of total weight. The ion selective sensing layer (103) further comprising: 0.2 to 3 percent lipophilic salt; 0.2 to 8 percent ionophore; 30 to 90 percent polymeric matrix; and 0 to 10 percent polypyrrole of total weight, configured for selective determination of ionic chemical analyte. The inert porous protective encapsulation (109), preferably made of Teflon is to avoid fouling of the sensor surface, to allow washing of the cap surface and to provide mechanical strength to the sensing composite.

[19] **Figure 4** illustrates the solid reference electrode (111) of the present invention. The reference electrode (111) further comprising: 1 to 30 percent graphite; 1 to 5 percent clay nanoparticles; 3 to 30 percent silver nanoparticles; 3 to 30 percent silver chloride; 1 to 30 percent chloride salt; and 0.1 to 5 percent carbon nanotubes of total weight. The conductive adhesive (16) is to secure the electrode (111) to the inert casing, holding the wire tracing and give adhesion with the sensing electrode (101).

[20] Taking the present invention as basis, the aquatic pollutant sensing system comprising: a chemical sensors having inert sensor tip substrate (107) and inert porous protective encapsulation (109) configured to detect aquatic pollutant; a solid reference electrode (111) configured to complete readout circuit for potentiometry measurement; a potentiometry readout circuit (105) configured to measure potential difference between chemical sensor and reference electrode; an analog to digital converter circuit configured to digitize sensor signal; a microcontroller circuit configured to convert

electrical signal to chemical concentration; and a radio transmitter circuit to transmit sensor and system data via wireless transmission.

[21] After having the present invention as basis of the sensing system, **Figure 5** illustrates flowchart of a method for preparing an aquatic pollutant sensing procedure of the present invention. The method for preparing an aquatic pollutant sensing procedure comprising: fabricating an inert sensor tip substrate (201); fabricating an inert porous protective encapsulation (203); securing electrochemical transducer nanocomposite and reference electrode in the sensor tip substrate with conducting adhesive (205); depositing ion selective layer on the electrochemical transducer (207); connecting the sensor and reference electrode wire traces to a potentiometry circuit (209); recording the emf signals in target analyte solutions, at least two points between 10^{-1} M and 10^{-6} M (211); and plotting emf values (mV) versus log activity of analyte concentrations (213).

[22] 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] An aquatic pollutant sensor comprising:
a transducer (101) as sensing electrode to convert analyte concentrations to voltage signals;
an ionselective layer (103) deposited on the transducer (101) to selectively transport target analyte to the said transducer (101);
a potentiometry readout circuit (105) to measure potential difference between chemical sensor and reference electrode;
an inert sensor tip substrate (107) having at least one sensor holder (1),(2), at least one reference electrode holder (3) and at least two tracks for wire traces (5), (10);
a protector (109) to provide mechanical strength, reduce fouling and allow cleaning; and
a reference electrode (111);
characterized in that
the transducer (101) further comprising an electrochemical transducer nanocomposite; the reference electrode (111) is in the form of solid;
and the protector (109) further comprising an inert porous protective encapsulation.
- [Claim 2] An aquatic pollutant sensor as claimed in Claim 1, wherein the reference electrode (109) further comprising:
1 to 30 percent graphite; 1 to 5 percent clay nanoparticles; 3 to 30 percent silver nanoparticles; 3 to 30 percent silver chloride; 1 to 30 percent chloride salt; and 0.1 to 5 percent carbon nanotubes of total weight.
- [Claim 3] An aquatic pollutant sensor as claimed in Claim 1, wherein the electrochemical transducer nanocomposite (101) further comprising: 1 to 30 percent graphite; 1 to 5 percent clay nanoparticles; 3 to 30 percent doped polypyrrole nanoparticles; and 0.1 to 5 percent carbon nanotubes of total weight.
- [Claim 4] An aquatic pollutant sensor as claimed in Claim 1, wherein the ion selective layer (103) further comprising: 0.2 to 3 percent lipophilic salt; 0.2 to 8 percent ionophore; 30 to 90 percent polymeric matrix; and 0 to 10 percent polypyrrole of total weight.
- [Claim 5] An aquatic pollutant sensor as claimed in Claim 2, wherein the clay nanoparticle further comprising: kaolin; bentonite; montmorillonite K 10; montmorillonite K 10; and illite.

- [Claim 6] An aquatic pollutant sensor as claimed in Claim 1, wherein the inert porous protective encapsulation (109) further comprising: protective windows having at least flat surface, at least 0.5mm thickness and at least 0.5µm pore size, having direct contact with or detached from the sensor tip substrate.
- [Claim 7] An aquatic pollutant sensor as claimed in Claim 1, wherein the inert porous protective encapsulation (109) having flat or curved surface which is detachable from the sensor tip substrate (107) and having fitting tracks.
- [Claim 8] An aquatic pollutant sensor as claimed in Claim 3, wherein the clay nanoparticle further comprising: kaolin; bentonite; montmorillonite K 10; montmorillonite K 10; and illite.
- [Claim 9] An aquatic pollutant sensing system comprising:
a chemical sensors having inert sensor tip substrate (107) and inert porous protective encapsulation (109) configured to detect aquatic pollutant;
a solid reference electrode (111) configured to complete readout circuit for potentiometry measurement;
a potentiometry readout circuit (105) configured to measure potential difference between chemical sensor and reference electrode;
an analog to digital converter circuit configured to digitize sensor signal;
a microcontroller circuit configured to convert electrical signal to chemical concentration; and
a radio transmitter circuit to transmit sensor and system data via wireless transmission.
- [Claim 10] A method for preparing an aquatic pollutant sensing comprising:
fabricating an inert sensor tip substrate (201);
fabricating an inert porous protective encapsulation (203);
securing an electrochemical transducer nanocomposite and reference electrode in the sensor tip substrate with conducting adhesive (205);
depositing an ion selective layer on the electrochemical transducer (207);
connecting the sensor and reference electrode wire traces to a potentiometry circuit (209);
recording the emf signals in target analyte solutions, at least two points between 10^{-1} M and 10^{-6} M (211); and
plotting emf values (mV) versus log activity of analyte concentrations (213).

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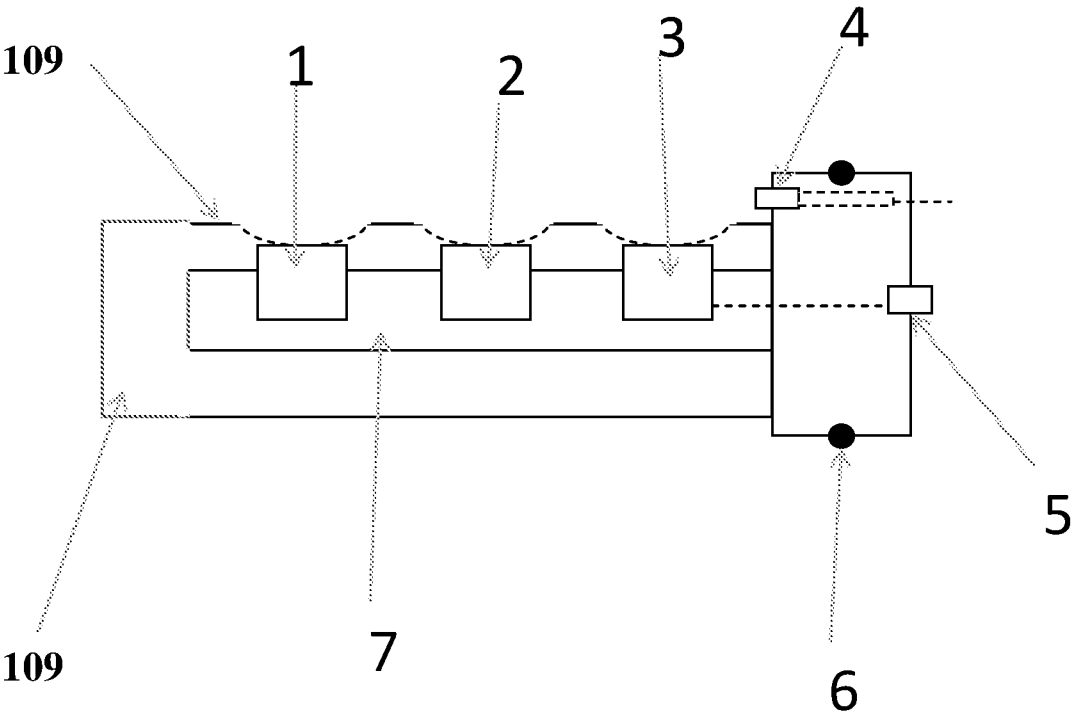
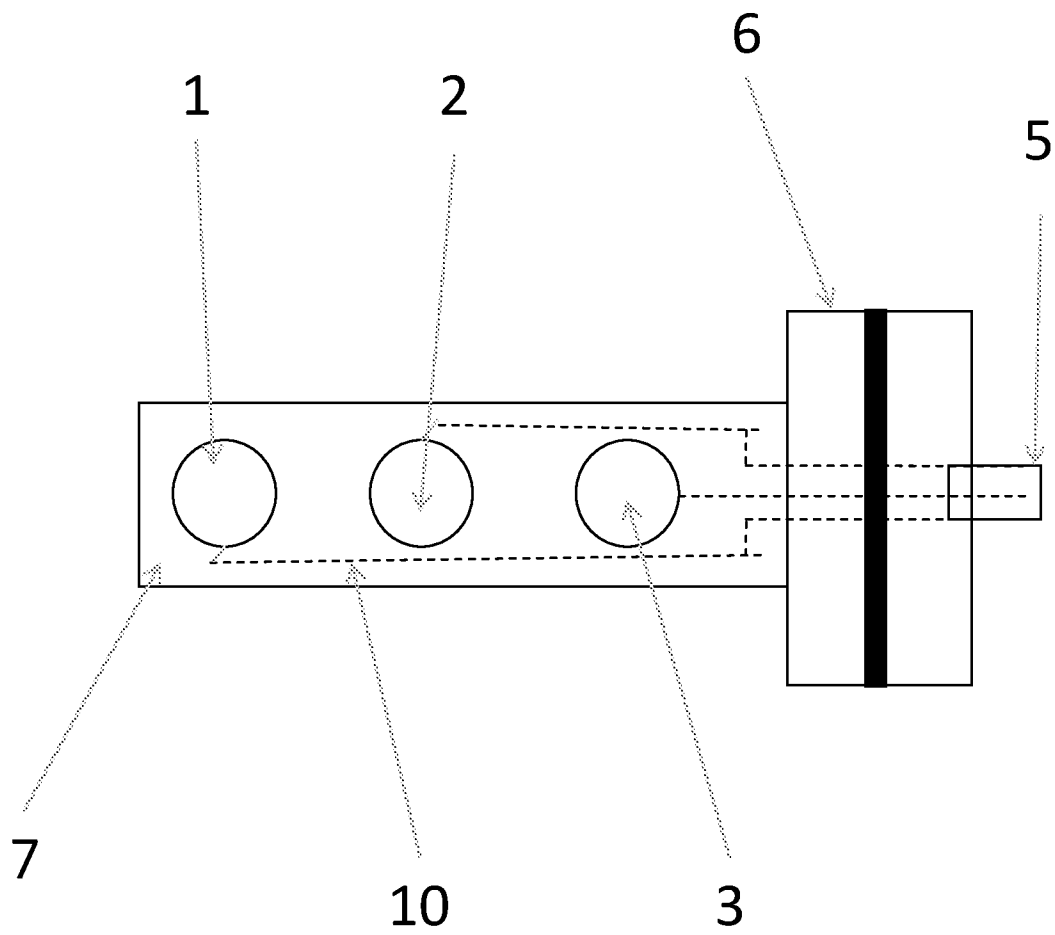


Figure 1

2/5**Figure 2**

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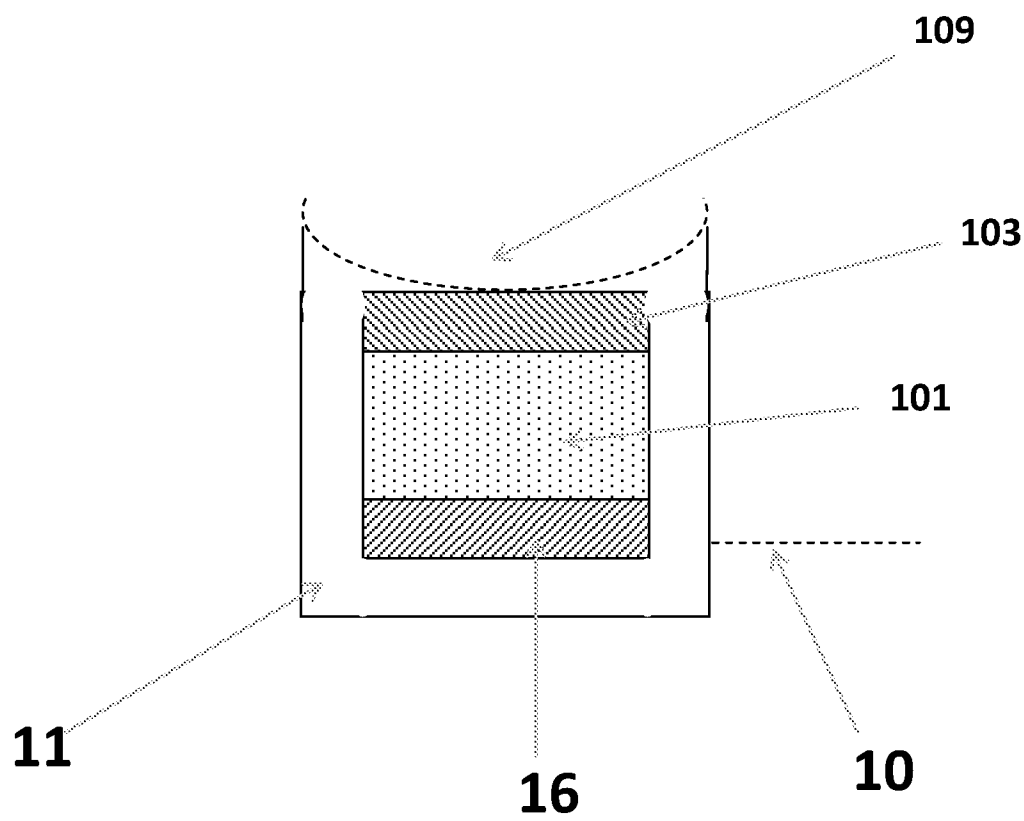


Figure 3

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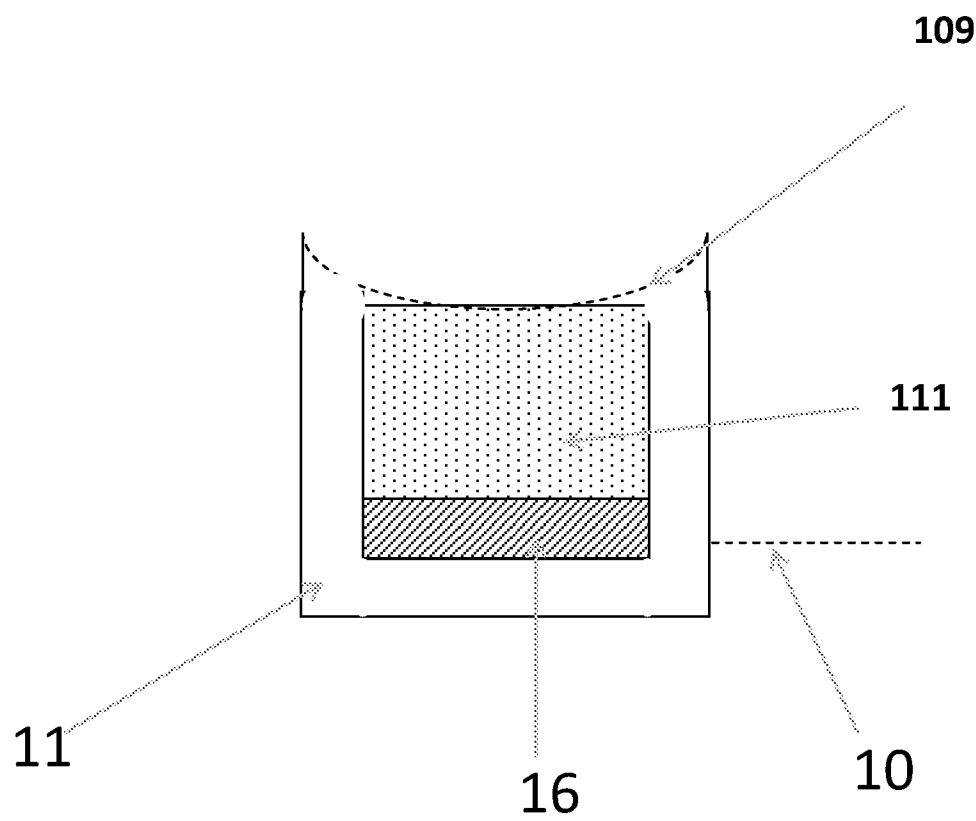
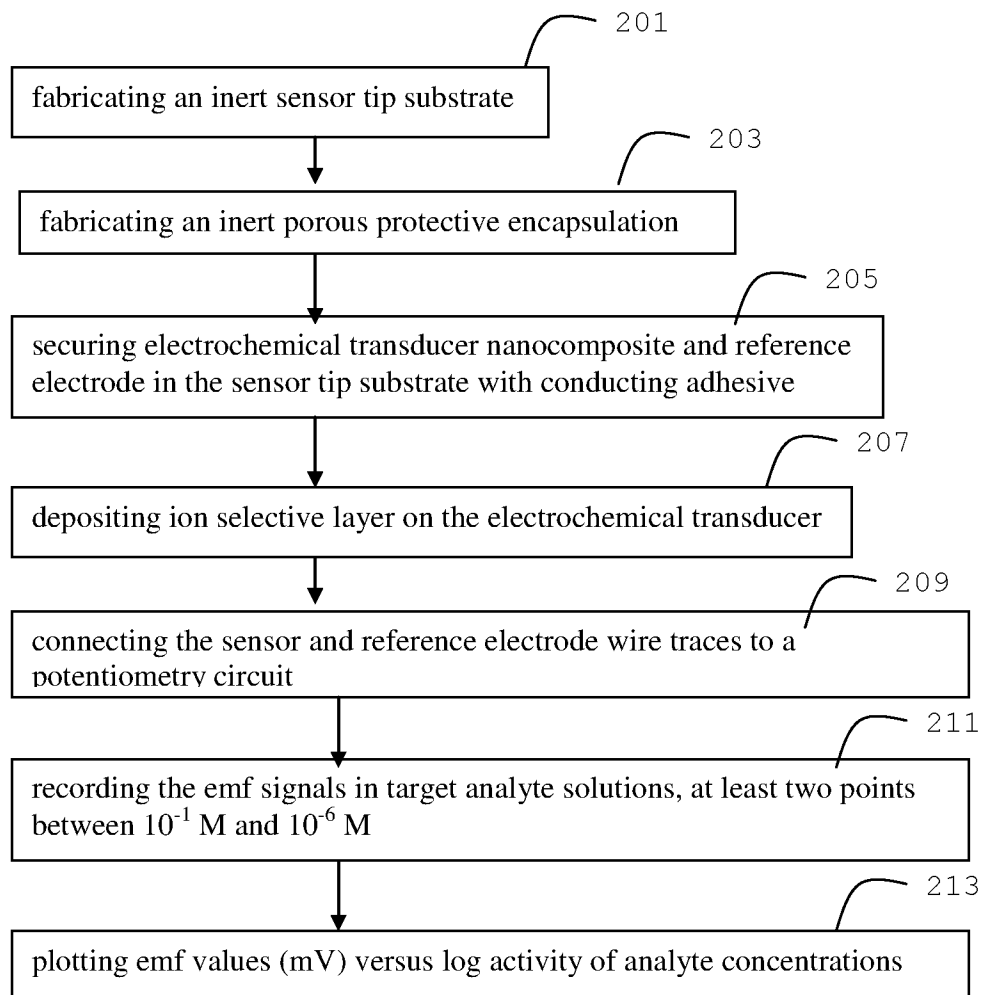


Figure 4

5/5**Figure 5**