TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

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1. GRAPHENE SENSOR FOR MOLECULAR DETECTION

Graphene is a form of carbon made of one layer of carbon atoms, which are arranged in a honeycomb shaped lattice. It is sturdy and light and has exceptional electric and thermal conducting properties. Many researchers are analyzing and implementing new methods to use graphene due to these exceptional characteristics.

A group of researchers from Bionanophotonic Systems Laboratory (BIOS), École polytechnique fédérale de Lausanne (EPFL) and Institute of Photonic Sciences (ICFO) has developed a unique sensor from graphene, which can detect proteins and drug molecules. This sensor is highly molecule sensitive and is developed by harnessing graphene's electric and optical properties.

Infrared absorption spectroscopy is the conventional method to detect molecules. The research team has improved this conventional method by using graphene. In the standard method, proteins or drugs molecules gets excited and vibrate differently according to their nature when exposed to light. The reflected light rays obtained from the vibrating molecules are used to identify and read the presence of these molecules. It is very difficult to detect vibrations of nanometrically-sized molecules using this method. This is due to the constrain that while the wavelength of the infrared photon directed at the molecule is around 6 micrometers (6,000 nanometers to 0.006 millimeters), only a few nanometers (about 0.000001 mm) can be read and measured by this method.

Under these inefficient circumstances a precise geometrical graphene is used to focus light rays on a precise spot on the surface of the protein or drug to obtain the vibrations of a nanometric molecule. By colliding electron beams and using oxygen to etch the surface of graphene, a nanostructure is formed on the surface of graphene. Localized surface plasmon resonance phenomenon is used to oscillate the electrons when light arrives in the graphene nanostructures making it possible to detect nanometric structures. Nature of the connecting bonds of the atoms can be determined in this method by analyzing the different range of vibrations generated from the bonds. The vibrations are used as fingerprints to identify the nature of molecules and also determine their health.

Graphene’s electrons oscillate in different ways when voltage is applied on them making them tune to different frequencies. Due to the oscillation of electron in different ways, graphene can read different vibrations of molecules placed on its surface. During this state, when protein is attached to graphene, a proper picture of the molecules structure can be obtained.

This novel method proves graphene’s extensive potential in the area of detection. This new graphene-based sensor can also be used on polymers and many other substances without the need to change or stressing the biological sample. The researchers are constantly working on large scale manufacturing of the sensor and hope to commercialize it by end of 2017.

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2. SMART TOOTHBRUSH WITH 3D SENSORS

Connectivity concept has grown immensely due to the Internet of Things (IoT). Connected living is being widely researched and analyzed by various companies and research institutions around the world.

In tune with the above mentioned trend, US-based Kolibree has developed a smart toothbrush. The smart toothbrush can be connected to phones and tablets for tracking and managing teeth brushing sessions. The company has also designed an app called Kolibree, which can be installed in Android and IOS smartphones and tablets. The brush informs the user about critical brushing zones and where extra attention is required. Data can be shared with dentists using the app, which is specially designed by Kolibree. This app also provides timely tips from dentists to maintain oral hygiene.

The tooth brush has a sleek body design and weighs around 64 grams. It has in-built wireless and three-dimensional (3D) motion sensors, magnetometer, gyro and 9-axis accelerometer to provide real-time feedback. The user's brushing motion is sensed and tracked with high precision by the 3D motion sensors. These sensors can also be used to control games on smartphones/tablets. The brushing statistics and data collected and stored in the application programming interface, helps in maintaining a better dental health and at the same time the gaming feature encourages kids to use this device.

The company is working on improving the quality of the product by increasing precision and efficiency in the motion sensors and ensuring top notch experience for the end users. The company closely works with dentists to provide dental consultation details, reminders to take pills, and medical prescriptions based on the brushing data collected. These are updated to the user's id and can be accessed by the user through the Kolibree app. This new strategy helps in differentiating Kolibree's smart tooth brush with other similar and competitive products in the market.

Since this novel product serves as a smart tooth brush and also as a gaming controller, it offers many advantages for consumers of all ages. The brush head has vibrations ranging from 4000 to 12500 RPM according to the brushing pattern of the user.

Even though electric tooth brushes have been in the market for a long time, an upgraded smart tooth brush with connectivity, gaming, data, statistics collection and dental advice facility will prove to be a great advancement for end users. Kolibree smart brush was commercialized in the beginning of 2015, and it is expected to impact the healthcare industry by the end of 2016.

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3. SKIN SENSOR FOR CONTROLLING GADGETS

A group of researchers from the Max Planck Institute for Informatics and the Saarland University have developed a skin-worn sensor called I-skin, which turns the human body into a touch sensitive surface. By using I-skin, mobile phones can be controlled easily. The sensor can be stretched and bent and can be worn on various parts of the body such as fingers, arms, and ear lobes. Using advanced material science, I-skin can be produced in various sizes and shapes. The sensor is capable of detecting pressure as input when touched. The current prototype developed by the researchers allows users to play music on smartphones and also adjust the volume.

I-skin uses touch and pressure sensors composed of multiple layers of silicon. The conducting parts of I-skin are built with carbon plant design management systems (PDMS) and the non-conducting parts are made of transparent PDMS.

Both the conducting and the non-conducting materials used to build these parts are biocompatible. The thickness of the sensor surface is between 0.3 mm to 0.7 mm. The I-skin also consists of a receiving metal electrode and a transmitting metal electrode--both made of soft metal. Wave signals are created from the transmitting electrode (which is at the bottom of the I-skin), and is received by the receiving electrode (which is at the top). When the user's fingers come close to the electrode, the mutual capacitance and amplitude of the received signal are reduced. The wave signals are created as the pressure from the users touch creates a contact between the electrodes and closes the circuit system. The electrodes also allow sensing of light touch and forceful pressure exerted by the user. The sensors are capable of capturing multitouch input and producing real-time data about touchdown and touch up events.

The research team has also addressed the aesthetics part of I-skin by providing design patterns and visual customization for the sensors. Designers can also transfer various existing graphics on the functional touch sensor according to the user's request.

The prototype was subjected to technical evaluation. In the tests, the sensor remained functional when stretched up to 30% of its full capacity, which proved that I-skin has more stretchability than human skin. Moreover, it could be bent to a radius of 5 mm, enabling its placement on curved locations of the human body. A high accuracy of over 92% for light touch contact and over 98% for firm pressure touch was also obtained from the results, confirming the robustness and accuracy of the touch sensor. I-skin is attached to the human body by using medical-grade adhesive, which can be removed easily without hurting or affecting the user's skin.

Currently, the I-skin has to be connected to a computer for powering it. The research team is working on developing a system that would harvest energy from the user's movements to power the I-skin. The I-skin is expected to enter the wearable device market by the end of 2017.

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4. PATENT ANALYSIS FOR CHEMICAL SENSORS

A chemical sensor is a device, which applies composition analysis to transform chemical information of a specific sample into analytical signals. The physical property or chemical reaction of the analyte of the system investigated is used to gather chemical information. A chemical (molecular) recognition system (receptor) and a physicochemical transducer are the two basic components of a chemical sensor. The physical properties of a chemical sensor are changed when the receptor interacts with analyte molecules. Due to this change, the appending transducer present in the sensor can gain an electrical signal. The kinetics and thermodynamics of a chemical reaction control the chemical sensor.

From the patent analysis done, it is evident that most of the patents filed in this domain are from the United States followed by Korea, China, Japan, and Germany. Companies such as Life Technology Cooperation, Samsung Electronics, and Sensirion AG have filed the most number of patents. A patent filed by Agency for Science, Technology and Research (US 20150206816) is about a chemical sensor package used in a highly pressured environment. National University Corporation has filed a patent (US20150143911), which deals about a physical/chemical sensor and the method used for measuring specific substances using the same sensor.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Chemical sensor package for highly pressured environment	July 23, 2015/ US 20150206816	Agency for Science, Technology and Research	Daniel Rhee Min Woo	A package for a chemical sensor including an encapsulation and a pressure balancing structure is disclosed. The encapsulation encapsulates a chemical sensor and has a hole for exposing a chemical sensitive part of the chemical sensor. The pressure balancing structure balances pressure applied to the chemical sensor at the chemical sensitive part.
Chemical sensors and methods of making and using the same	July 23, 2015/ US 20150204835	Liangming Wei	Liangming Wei	The present application relates to methods of making a chemical sensor including dispersing mesoporous silica structures, an organic solvent, and water to form a composition; and combining one or more chemical sensing molecules with the composition. In some embodiments, the composition includes not more than about 0.6 g of water relative to about 1 g of the mesoporous silica structures. In some embodiments, the chemical sensing molecules include a silane coupling group coupled to a chemical sensing group. Also discloses herein are chemical sensors and methods of using the chemical sensors. The chemical sensors may, in some embodiments, exhibit superior detection of one or more analytes.

Warewash machine chemical sensor and related system and method	July 1, 2015/ EP 2887856	PREMARK FEG LLC	Dickey Larry M	A flow through chemical sensor (68, 70, 72) includes a housing (80) having a through passage (86) along which chemical can flow, a sidewall of the housing having first (88) and second openings (90) that communicate with the through passage (86). A first electrode (92) is mounted on the housing (80) and aligned with the first opening (88), the first electrode (92) of a plate configuration with a unitary depression (108) that extends through the first opening (88) and to a peripheral edge of the through passage (86). A second electrode (94) is mounted on the housing (80) and aligned with the second opening (90), the second electrode (94) of a plate configuration with a unitary depression (110) that extends through the second opening (90) and to the peripheral edge of the through passage (86). A method of detecting presence or absence of chemical is also provided.
Physical/ chemical sensor and method for measuring specific substance	May 28, 2015/ US 20150143911	National University Corporation	Kazuhiro Takahashi	[Problems to be solved] A physical/chemical sensor that enables reduction of the size of the sensor and formation of arrays of the sensors is provided. The sensor can sense small change of surface stress and can measure mass of fixed specific substance. Also, a measuring method of the specific substance using the sensor is provided. [Means for solving problems] A physical/chemical sensor has a movable membrane (**3**) having a diaphragm structure provided to form a hollow section (**2**) between the movable membrane (**3**) and a light receiving surface of a light receiving element (**1**), a first piezoelectric membrane (**4**) that is provided on a front-side surface or a backside surface of the movable membrane (**3**) and that excites the movable membrane (**3**), and a second piezoelectric membrane (**5**) that is provided on the front-side surface or the backside surface of the movable membrane (**3**) and that senses a voltage caused by oscillation of the movable membrane (**3**). A measuring method using the physical/chemical sensor applies a voltage to the first piezoelectric membrane (**4**) while changing frequency and senses resonance frequency by sensing a voltage outputted from the second piezoelectric membrane (**5**).
Opto-chemical sensor	May 20, 2015/ EP 2872876	Joanneum Res Forschungs GMBH	WOLF CHRISTIAN	In an opto-chemical sensor, comprising a sensor layer attached to a carrier and formed from spun nano fibres doped with a luminescent dyestuff, wherein the emission property of said sensor layer can be changed in a gas or liquid phase after excitation with electromagnetic radiation by substances which are to be detected such as O2, CO2, lactate, glucose, NH3, SO2, H2O2, nitrogen oxides, halogenated hydrocarbons and ions or measurement variables which are to be determined, such as the pH-value, moisture and temperature in a gas or liquid phase, the sensor layer is formed from nano fibres with a diameter between 50 nm and 1000 nm and the nano fibres are doped with at least one luminescent dyestuff selected from the group consisting of metal porphyrins, benzoporphyrins, azabenzoporphyrins, napthoporphyrins, phthalocyanines, polycyclic aromatic hydrocarbons, particularly perylenes, perylene diimines, pyrenes; xanthene dyestuffs, azo dyestuffs, bodipy dyestuffs, azabodipy dyestuffs, cyanine dyestuffs, metal-ligand complex dyestuffs, particularly bipyridines, bipyridyls, phenantrolines, coumarins and acetyl acetonates of ruthenium and iridium; acridine dyestuffs, oxazin dyestuffs, coumarins, azaannulenes, squarines, 8-hydroxyquinolines, polymethines, luminescent nano particles, such as quantum dots, nano crystals;

				carbostyryls, terbium complexes, inorganic phosphors or dyestuffs of the aforementioned classes derivatized or bound to ionophores (e.g. crown ether).
Method for determining at least one physical, chemical and/or biological measured variable by means of optical sensors, and turbidity sensor	April 16, 2015/ US 20150103344	Endress + Hauser Conducta Gesellschaft für Mess- und Regeltechnik mbH + Co. KG	Thilo Kratschmer	A turbidity sensor and a method for determining at least one physical, chemical and/or biological measured variable of process automation in a medium by means of at least one optical sensor, comprising the steps of sending transmission signals into the medium, wherein the transmission signals are converted into received signals by interaction with, especially by scattering from, the medium as a function of the measured variable; receiving the received signals; and converting the received signals into the measured variable as a function of environmental conditions at the location of installation and, adjusting the sensor based on a calibration graph corresponding to environmental conditions at the location of installation.
A chemical capacitance sensor	July 1, 2015/ WO 2015054195	Honeywell International Inc.	Beck, Scott Edward	An example approach and structure for providing a chemical sensor, having an electrode that may receive a fluid that is passed on towards a dielectric between the electrode and one or more other electrodes. A capacitance between the electrodes may be changed by the dielectric which is affected by a parameter of the fluid. Measuring a change of the capacitance may indicate a magnitude of the parameter. The electrode receiving the fluid may have one or more layers of metal particles that by design of the particles and their arrangement can result in determined pore sizes and routes through the electrode for a controllable porosity of the electrode
Nanoscale spintronic chemical sensor	March 12,2015/ US 20150071821	Thomas M. Crawford	Thomas M. Crawford	In general, the present disclosure is directed toward a novel hybrid spintronic device for converting chemical absorption into a change in magnetoresistance. This device uses a novel magnetic material which depends on the attachment of an organic structure to a metallic film for its magnetism. Changes in the chemical environment lead to absorption on the surface of this organometallic bilayer and thus modify its magnetic properties. The change in magnetic properties, in turn, leads to a change in the resistance of a magnetoresistive structure or a spin transistor structure, allowing a standard electrical detection of the chemical change in the sensor surface.
Chemical sensor with sidewall spacer sensor surface	March 5,2015/ US 20150064829	Life Technologies Cooperation	Paul-David Rostocki	In one implementation, a chemical sensor is described. The chemical sensor includes chemically-sensitive field effect transistor including a floating gate conductor having an upper surface. A dielectric material defines an opening extending to the upper surface of the floating gate conductor. A conductive sidewall spacer is on a sidewall of the opening and contacts the upper surface of the floating gate conductor.

Fluorescence chemical sensor for detecting 2,4,6-trinitrophenol and preparation method of fluorescence chemical reactor	February 25, 2015/ CN 104371111	Jiangnan University	Wei Wei	The invention provides a fluorescence chemical sensor for detecting 2,4,6-trinitrophenol and a preparation method of the fluorescence chemical reactor, belonging to the technical field of preparation and chemical analysis of functional high polymer materials. The fluorescence chemical sensor has a chemical structure shown in the specification. The preparation method of the fluorescence chemical sensor comprises the following steps: (1), in the presence of an acid-binding agent, performing condensation polymerization in an organic solvent by using phosphonitrilic chloride trimerl and curcumin to obtain a solution; (2), separating a solid product in the solution, washing and drying to obtain the fluorescence chemical sensor. The fluorescence chemical sensor based on ring-crosslinking type polyphosphazene, disclosed by the invention, is simple and mild in preparation process, has excellent thermal stability, chemical stability and fluorescence characteristics, can be used for realizing specific identification and detection of 2,4,6-trinitrophenol in a liquid phase, is high in sensibility, is suitable for the fields of trace explosive detection and environment monitoring, and is favorable for realizing industrial production.

Exhibit 1 lists some of the patents related to chemical sensors.

Picture Credit: Frost & Sullivan, WIPO

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