TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

26th September 2014

1. EFFICIENT TECHNOLOGY FOR DETECTING CHEMICAL WARFARE GASES

Nuclear, biological and chemical (NBC) warfare is an unconventional warfare threat looming large over the world. Compared to conventional warfare, nuclear warfare is more destructive in range and extent of damage. Biological warfare uses toxic materials produced from pathogenic organisms or artificially manufactured toxic substances to deliberately interfere with the biological processes of the host. These substances work to kill or incapacitate the host. Chemical warfare is the term used to describe the use of chemical agents as weapons to injure or kill humans, livestock or plants. Chemicals can be dispensed as liquids, vapors, gases, or aerosols.

The chemical warfare gas detection systems available in the market, which can be based on physical or enzymatic methodologies, can have deficiencies, such as low selectivity or selectivity, susceptibility to false alarms.Moreover, they can be expensive.

Artificial noses have potential to provide enhanced sensitivity and selectivity for security applications by identifying and analyzing the specific components of an odor. Enoses end to use an array of chemical sensors, each one having partial sensitivity and selectivity and signal processing and pattern recognition capapbility,

A group of researchers at the Polytechnic University of Valencia, Spain have developed an electronic nose prototype for the detection of chemical warfare gases, mainly nerve gases such as Sarin, Somun, and Tabun. The electronic nose consists of fifteen commercial sensors, a data acquisition system and a computer connected to this system. The nose registers the gases in the environment through the sensors and processes the data obtained using a recognition pattern and warns of the presence of chemical warfare gases.

The researchers explained that the metal oxide semiconductor sensors respond to the gases in a characteristic way. The system registers the signs of gases through the sensors. The signs are mathematically processed to obtain the different recognition patterns to discriminate between the different gases.

The researchers evaluated the performance of the electronic nose by performing various tests in the laboratory using gas simulants, which react in the same way but are less toxic. According to the researchers, the development of the technology is almost complete; it is expected to find application in the security sector. They also stressed that there are still many steps to be taken before the technology is commercially implemented.

With regard to its possible modes, the researchers explained that the electronic nose could be both portable and fixed. It can be used to take measures in concrete settings where a chemical attack is suspected. It can also be used for continuous environment monitoring. The researchers predicted that this efficient device could be used in transport infrastructure, such as airports or train stations, and also in other national security services.

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2. SENSOR FOR DETECTING ULTRA HIGH-SENSITIVE TINY MOLECULES

Detecting tiny molecules is vital in chemical sensing. There are various devices on the market that are being used in the medical industry for chemical sensing. However, these devices may no be able to effectively detect tiny single molecules from available samples, such as blood. There is a need for a device that can detect tiny single molecules from the available samples. The device should provide accurate results, must be easy to use and cost efficient.

To address the above challenge, researchers from the A*STAR Institute of Materials Research and Engineering have developed a sensor which can efficiently guide and place molecules into position. The sensor is capable of detecting tiny molecules; it comprises small gold plates.

The researchers developed the sensor by depositing a thin titanium film between the gold plates. This apparatus acts as a powerful plasmonic nanoantenna, which amplifies the radiation from small molecules and helps to detect tiny single molecules. A titanium film is used because of the high surface area; this film exhibits magnetic properties. Titanium oxidizes in the air and forms stable titanium dioxide. Titanium dioxide has good insulating characteristics and has dissimilar properties than the gold plates. The sensor is also covered with an organic solution, which prevents molecules, such as proteins binding with the gold. These proteins are then attracted toward the titanium pad. Thus, molecules get placed correctly in the electromagnetic hotspot, leading to the detection of tiny molecules efficiently.

The product will find use in medical and biological diagnostics, where tracing a tiny quantity of molecule is important for chemical sensing. With further development, this sensor will also be used to detect and differentiate several molecules using one chip. The sensor is cost efficient, provides accurate results and is very easy to use.

This project was supported by the National University of Singapore. The researchers are working on increasing the sensitivity of the sensor. They are planning to use multi agent sensing in one chip. The project is expected to be commercialized in two to three years' time. Once the product is fully developed, it has potential to be well received by users because it reduces the amount of sample required and enhances molecular sensitivity.

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3. WEARABLE SENSOR TO DETECT AIRBORNE CHEMICALS

Wearable electronics have been gaining traction across various sectors, such as healthcare, defense, and consumer electronics. Sensors are playing a very important role in wearable electronics. Wearable electronics in healthcare can use nanoelectronic sensors, to detect airborne molecules. Conventional nanoelectronic sensors sense the charge transfer between the sensor and the molecule in the in air, but this technique can have a slow detection rate for

sensing diseases. As these methods are expensive and complicated, there is a need for a fast, cost effective, and accurate device that can detect airborne chemicals.

To address the above challenge, researchers from the University of Michigan have developed a wearable nanoelectronic graphene vapor sensor to detect airborne chemicals by heterodyne mixing. This device acts as an indicator in the diagnosis of medical conditions, such as diabetes by detecting acetone in the body.

The researchers have used graphene because of its properties such as high electrical conductivity and inherent strength. Heterodyne mixing is used to generate frequency by mixing two or more signals. The mixing in this device enables interaction at high frequency between the dipoles which is associated with the airborne molecules and the sensor. The graphene used to design the device helps to achieve faster response because of its electrical conductivity property at high frequency and it also helps to increase the sensitivity of the device. The nano sensors used in this device can sense the molecules at a very small ratio such as parts per billion. Thus, the sensor helps to detect a wide array of airborne molecules. These sensor are embedded on the chromatography system. The complete chromatography system is a badge-sized device, which can be integrated on a single chip. The chip is worn on the body as a wearable sensor to monitor health conditions.

The graphene-based wearable sensor will be utilized in medical labs to detect biomarkers for diseases, such as diabetes. The device will also be used to monitor oxygen and nitric oxide, which is exhaled and released from the body respectively. These biomarkers will be used to detect lung disease, blood pressure, and anemia. Because of the use of graphene and its high electrical conductivity, the device works faster and it is highly reliable. Thus, the graphene based wearbale sensor detects a wider array of chemicals.

This project was self-funded by the University of Michigan. The researchers are currently working on using the device in chemical labs to detect harmful chemicals. The device can be used to detect a variety of airborne chemicals released through the skin. The researchers are also working on modifying the device to enable its use for specific target airborne biomarkers, such as detecting blood pressure. Once commercialized, the graphene-based

molecular sensor will have opportunities attract users who need to constantly keep track of their health condition. .

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4. RECENT PATENTS IN THE FIELD OF GAS SENSORS

A key area for gas sensors is industrial safety, for instance, to prevent worker exposure toxic or combustible gases. They are also used to measure the gases in the air via different technologies, such as electrochemical, metal oxide semiconductor, catalytic bead, infrared, photoionization, surface acoustic wave, and so on. Single-gas detectors can protect individuals, while multi-gas detectors with intelligent electronics can monitor concentrations of such gases as carbon monoxide, hydrogen sulphide, ammonia, and so on.

A recent patent in gas sensing (WO/2014/143175), assigned to Mine Safety Appliances, pertains to a system with at least one electrochemical gas sensor to detect an analyte gas within the system's housing.

From 1959 to September 2014, approximately 5,06345 patents have been registered under gas sensing. In September 2014, approximately 700 patents have been registered under gas sensing. The trend in 2014 suggests that gas sensors have a strong demand from different industries, such as construction, building, oil, and gas, and chemicals. The increase in safety regulations one factor driving the demand for gas sensors.

The global market for gas sensing is increasing, reflected in increase in the number of applications, such as automotive (exhaust oxygen sensors, cabin air quality sensors), environmental monitoring, HVAC/demand-controlled ventilation, boiler control, fire detection, consumer (including residential CO detection, breath alcohol detection), detection of harmful gases in mines and home safety. Honeywell International has approximately 1167 patents registered under gas sensing. Gas sensors have growth opportunities in diverse applications, including homeland security, industrial safety, oil and gas, automotive, consumer,

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
GAS SENSOR INTERROGATION	18.09.2014; WO/2014/143175	MINE SAFETY APPLIANCES COMPANY	SCHEFFLER, Towner Bennett	A method of testing a system (100) having at least one electrochemical gas sensor (100), such as an amperometric gas sensor, for detecting an analyte gas within a housing (102) of the system (100), the housing (102) having an inlet (104), the at least one electrochemical gas sensor (110) including an electrically active working electrode (150a) in fluid connection with the inlet (104) of the system (100), the method including biasing the electrically active working electrode (150a) at a first potential, to detect the analyte gas and biasing the electrically active working electrode (150a) at a second potential, different from the first potential, such that the at least one electrochemical gas sensor (110) is sensitive to a driving force created in the vicinity of the inlet (104) to test at least one transport path of the system (100). The method may further include creating the driving force in the vicinity of the inlet (104) of the housing (102) of the system (100) and measuring a response of the electrically active working electrode (150a) to the driving force. Said system (100) is therefore suitable for checking the performance of the electrochemical gas sensor (1), particularly to check that gas transport inside the system (100) is not prevented by diffusion blockage. The electrochemical gas sensor (110) is interrogated at bias voltages sensitive to different gas analytes, one being a target gas (e.g H2S) while the other being provided by, for instance, exhaled breath (e.g. C02).
GAS SENSING WITH TUNABLE PHOTONIC RADIATION FILTER ELEMENT	18.09.2014; WO/2014/143049	DRAEGER SAFETY, INC.	MURJADA, Gary, Francis	Using a gas detector, photonic radiation is emitted over a first range of frequencies and through a pathway. The gas detector includes at least one broadband light source, at least one detector, and an electronically tunable filter element disposed in the pathway and between the at least one light source and the at least one detector. The electronically tunable filter element allows a window of radiation frequencies to pass through the filter and suppresses other radiation frequencies. The electronically tunable filter element is tuned to allow different windows of radiation frequencies to pass through the filter. Photonic radiation energy that passes through the tuned electronically tunable filter element and impinges on the detector is measured to form a spectral absorption signature characterizing constituents of gas in the pathway. Related apparatus, systems, techniques, and articles are also described.
GAS SENSORS AND METHODS OF CALIBRATING SAME	18.09.2014; WO/2014/142829	BASCOM-TURNER INSTRUMENTS, INC.	MAKRIDES, Alkis C.	A method is provided for calibrating a thermal conductivity sensor in a first medium A from measurements in a second medium B. The method includes maintaining the sensor at a substantially fixed temperature T1, and measuring a heat flux IB(T1) from the thermal element in the second medium B. A corresponding heat flux IB(T1) in the first medium A is calculated using known thermal conductivities of the first medium A and the second medium B.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
GAS DOPING SYSTEMS FOR CONTROLLED DOPING OF A MELT OF SEMICONDUCTOR OR SOLAR-GRADE MATERIAL	18.09.2014; WO/2014/141309	MEMC ELECTRONIC MATERIALS S.P.A	HARINGER, Stephan	A crystal pulling apparatus for producing an ingot is provided. The apparatus includes a furnace and a gas doping system. The furnace includes a crucible for holding a melt. The gas doping system includes a feeding tube, an evaporation receptacle, and a fluid flow restrictor. The feeding tube is positioned within the furnace, and includes at least one feeding tube sidewall, a first end through which a solid dopant is introduced into the feeding tube, and an opening opposite the first end through which a gaseous dopant is introduced into the furnace. The evaporation receptacle is configured to vaporize the dopant therein, and is disposed near the opening of the feeding tube. The fluid flow restrictor is configured to permit the passage of solid dopant therethrough and restrict the flow of gaseous dopant therethrough, and is disposed within the feeding tube between the first end and the evaporation receptacle.
GAS SENSOR	18.09.2014 WO/2014/141730	HITACHI AUTOMOTIVE SYSTEMS, LTD	NAKANO Hiroshi	A gas sensor which prevents deterioration and malfunctioning of a sensor element caused by activation when a liquid has adhered to the sensor element, and removes the liquid in a short time, and with low power consumption. The gas sensor comprises a first heat generating body, and a second heat generating body that is formed around the first heat generating body so as to be larger than the surface area formed by the first heat generating body. The gas sensor measures the quantity of a gas by heating the first heat generating body to a prescribed temperature. When the gas sensor activates, the second heat generating body is heated, the heat generation amount of the first heat generating body is limited for a prescribed period, and thereafter the temperature of the first heat generating body is increased to the prescribed temperature.
SENSOR APPARATUS AND METHOD FOR DETECTING A GAS IN A GAS MIXTURE	18.09.2014; WO/2014/139764	ROBERT BOSCH GMBH	NOLTE, Philipp	The invention relates to a sensor apparatus (100) for detecting a gas (118) in a gas mixture (110). The sensor apparatus (100) comprises a measuring electrode (102) with a measuring surface (111) for coming into contact with the gas mixture (110), a reference electrode (104), an electrolyte (106) which is arranged between the measuring electrode (102) and the reference electrode (104), and a diffusion-limiting covering layer (108) which is arranged on a surface (112) of the reference electrode (104) facing away from the electrolyte (106), wherein an inner surface (114) of the covering layer (108) makes contact with the reference electrode (104), and an outer surface (116) of the covering layer (108) is designed to come into contact with the gas mixture (110). With a sensor geometry according to the model of a broadband lambda probe, the gas mixture on the measuring surface on the measuring electrode can be modified by an oxygen pump cell. This corresponds to electrochemical pumping-out or pumping-in of oxygen.
MINIATURIZED GAS SENSOR DEVICE AND METHOD	18.09.2014; WO/2014/143782	THE CLEVELAND CLINIC FOUNDATION	HUNTER, Gary W.	Various embodiments of a gas sensor device and method of fabricating a gas sensor device are provided. In one embodiment a gas sensor device includes a base substrate, an electrolyte layer disposed on the base substrate and a plurality of potentiometric sensor units electrically coupled to the base substrate. Each potentiometric sensor unit includes an electrolyte layer disposed on the base substrate, a sensing electrode comprising tungsten oxide (WO_3) and platinum (Pt), a reference electrode comprising Pt, and a plurality of connectors coupled to the plurality of potentiometric sensors to connect the plurality of potentiometric sensors in series.

Exhibit 1 lists some of the patents related to gas sensing.

Picture Credit: Frost & Sullivan

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