TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

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1. BIOMETRIC SENSORS COULD BOOST DRIVER SAFETY

There has been keen interest and activity in the "quantified self" domain; which involves measuring and tracking key biological, physical, or behavioral data about oneself (such as heart rate, blood pressure, and exercise).

The concept of the quantified self is being leveraged to be applied to vehicles. There has been significant development underway at key automakers, universities, sensor companies, and component or systems providers in biometric sensors that would be used in the vehicle measure of key biological parameters to detect a driver's fatigue level, stress level, or even his physiological condition (such as pulse, breathing, heart rate, and so on).

Biometric information about the driver could be used to improve driver concentration, for example, by disabling cell phone signals if the driver is experiencing stress, turning the radio off, or even as an input to manage the vehicle's safety systems (such as tapping the brakes).

Certain models of Lexus vehicles have used cameras in the vehicle cabin, while some Mercedes-Benz vehicles have used steering sensors to detect driver drowsiness and issue a warning to drivers that they may want to take a break.

Biometric sensing technologies for in-vehicle use that have been investigated include: brain wave sensing electrodes embedded in the headrest of the car seat to evaluate a driver's stress level; electrocardiogram (ECG) sensors embedded in the seat to detect heart rate variation, breathing, and alertness; respiration or heat rate sensors in the seat belt; heart rate sensors in the steering wheel or seat; diabetes (blood sugar) monitors; sensors that can detect steering-wheel movement (which varies more when a driver is drowsy) and the driver's posture slump; and so on. Early warning signs of driver fatigue can include a slower heart rate, slower breathing rate, and a slump in posture.

Information about metrics such as the driver's heart rate, blood pressure, respiration, galvanic skin response, or glucose level may be able to shed light on or predict the driver's emotional state; for example, the driver may be found to be considerably stressed or angry. Actions, such as playing music, could be initiated to alleviate the stress or anger.

ECG sensors placed in the steering wheel to monitor the heart rate could be useful in detecting abnormal heart activity or an imminent heart attack.

Technische Universitaet Muenchen (TUM) and BMW have developed an instrumented steering wheel capable of monitoring a driver's health status while driving. The system includes heart rate, skin conductance, and oxygen saturation sensors.

Information about the driver's biometric responses and condition could also potentially facilitate assistance in the event of an accident. Information about the driver's condition could help emergency responders to deal more effectively with the situation.

However, biometric sensors, which detect biological responses, are not likely to be installed in mass-produced vehicles over the near term (about 3 to 5 years). Medical, privacy, and regulatory issues need to be dealt with in order to drive wider adoption of such sensors in vehicles. Furthermore, biometric sensors should not be a distraction to the driver, and he should be able to control the system.

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2. IMPROVED X-RAY WAVELENGTH MEASUREMENT

An X-ray is a higher energy type of electromagnetic radiation that travels at the speed of light. Its wavelength is much shorter than that of ordinary light while its frequency is greater. As there is a direct relationship between the energy and the frequency of electromagnetic waves, X-rays are more energetic and penetrating than light waves. Being more energetic, X-rays are able to travel through objects that ordinary waves cannot penetrate.

Applications for X-rays include medical (radiology), dentistry, security (such as baggage inspection at airports or trace explosives detection), materials

analysis, environmental studies (for example, particulate matter), non-destructive testing in industry, and astronomy.

Sources in the National Institute of Standards and Technology (NIST) have noted that X-ray wavelengths can be measured by passing the beam through special crystals and measuring the angle which the existing rays form with the original beam. The crystal is generally mounted on a rotating device, which spins it in two different positions where a spectral line is observed. However, the digital encoder, which translates the crystal's motion into an angle measurement, may have limited accuracy.

Larry T. Hudson and his associates at NIST have discovered an approach to significantly reduce errors in this measurement, using laser beams, which bounce off a mirrored polygon that is rotated on the same shaft that would carry the crystal. This method enables the team to advantageously use additional mathematical shortcuts. Using new NIST sensing instrumentation (for example, a redesigned electronic nulling autocollimator) and analysis, the X-ray angles can be measured routinely with an uncertainty of 0.06 arc seconds--an accuracy which is more than three-fold higher than that of an uncalibrated encoder. The reduction is described as being sufficiently significant to set world records in X-ray wavelength measurement.

In fields depending on X-ray sensing, the ability to calibrate measurement devices to have greater precision will, for example, provide a greater understanding of varied newly designed material. Materials can have complicated crystal structures leading to unusual effects such as high-temperature superconductivity. Researchers' work can enable an improved understanding of the relationship between the structures and properties of innovative materials.

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3. ULTRA-THIN ACCELEROMETERS

Accelerometers are widely used in diverse applications, such as industrial, automotive, aerospace, and medical applications to measure static linear acceleration forces (such as the force of gravity) or dynamic acceleration forces (caused by moving or vibrating the accelerometer).

Three-axis accelerometers allow for measurement in the X, Y, and Z axes or dimensions. Such capability can enable smoother and more precise motion recognition as well as more accurate measurement of tilt over an unrestricted range. The tri-axis accelerometer is, according to Kionix, quickly becoming an industry standard, as it is the fastest and easiest way to ensure constant detection within a 360 degree area.

MEMS (microelectromechanical systems)-based accelerometers provide key benefits over conventional electromechanical accelerometers, such as reduced size, weight, and power consumption; high sensitivity; wide dynamic range; and low noise.

US-based Kionix has leveraged the company's capacitance-based technology and proprietary deep-silicon reactive ion etching (DRIE) plasma micromachining technology—originally developed at Cornell University—to create ultra-thin, tri-axial accelerometers. The KX112 (measuring 2 mmx2mmx0.6 mm thick) and the KXCJB (3 mm x 3 mm x 0.45 mm thick) are mainly suitable for mobile, wearable, and PC or table computer applications. Moreover, Kionix, a wholly owned subsidiary of ROHM Co. Ltd. (Japan), has planned to expand the portfolio of ultra-thin, low-power accelerometers to include automotive and heavy-duty industrial applications.

The KX112 ultra-thin accelerometer is highly suitable for compact designs in health, medical, or wearable applications. The device provides 16 bits of resolution and has excellent stability. It has built-in digital algorithms to detect motion for power management, free-fall for detection protection or warranty monitoring, an orientation engine for portrait or landscape detection, and tap/double tap for functioning as a user interface. The device has been described by Kionix sources as having the largest FIFO (first in, first out)/FILO (first in, last out) buffer available in a mass-produced accelerometer. The availability of 2,048 bytes helps to record a great deal of data while conserving power.

The KXCJB accelerometer helps to enable thinner, smarter end-products, such as smartphones, PCs or tablets, hard disk drives, or more compact wearable devices such as activity monitors or smart watches. The ultra-thin form factor can enable embedding motion sensing or detection in new, innovative devices, such as badges, access cards, or smart cards. The ultra-thinness can also better allow for maintaining a low profile when the device is mounted on thin structures, such as those made of glass or plastic.

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4. RECENT PATENTS IN THE FIELD OF CHEMICAL SENSING

Opportunities for chemical threat agent detection systems are being driven by increasing threats of terrorist attacks. Chemical threats include harmful and toxic industrial chemicals as well as chemical warfare agents (including explosives). There is a need and opportunity for improving the ability to sensitively and selectively identify, monitor, and provide early warning detection of chemical threat agents, including stand-off detection of chemical agents from a distance.

Key technologies for advanced chemical agent detection that have been generating interest include ion mobility spectroscopy (a key incumbent technology), surface acoustic wave (SAW), Raman spectroscopy, terahertz technology, electronic noses, LIDAR, laser induced breakdown spectroscopy, and nanotechnology.

Growing economies in Asia, such as, China, and India, are keenly interested in boosting their security, including, their chemical agent detection capabilities. The USA is the vital market for chemical detection. A majority of the patent concentration has been observed in USA. Developing countries are accelerating investments in defense, leading to increased adoption rates. Chemical detector markets in developed countries, such as the United States, and UK, are well-established, but there are still needs for improved selectivity, stand-off detection capability, networkability, further minimizing of false alarms. Preparing for the aftermath of a chemical agent attack is a high-priority mission of US Homeland Security policy and decision makers. Homeland security applications for chemical detection include screening of cargo

containers, subways, airports, critical infrastructure, toxic industrial chemicals, infrastructure (such as public buildings), as well as chemical attribution signature (CAS) analysis to attribute toxic chemicals or materials to their source.

A recent patent, A Chemical Capacitance Sensor (WO/2015/054195), assigned to Honeywell International Inc., pertains to a chemical sensor that receives a fluid that is passed on toward the dielectric between the electrode and other electrodes. Measurement of the change in capacitance between the electrodes can indicate the magnitude of the parameter (that is, chemical of interest).

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
A CHEMICAL CAPACITANCE SENSOR	16.04.2015; WO/2015/054195	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	12.03.2015; US20150071821	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	05.03.2015; US20150064829	LIFE TECHNOLOGIES CORPORATION	Keith G. FIFE	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.
BIOMIMETIC CHEMICAL SENSORS USING NANOELECTRONIC READOUT OF OLFACTORY RECEPTORS	05.03.2015; US20150065363	Alan T. Johnson, JR.	Alan T. Johnson, JR.	The present invention provides biomimetic sensor devices that utilize proteins—such as G-protein coupled receptors—and are useful in high-sensitivity analysis of analyte-containing samples. These sensors may be used to determine the presence or concentration of one or more analytes in a sample. The invention also includes methods of fabricating the devices and methods of using the devices to assay samples.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
ANGLE OF INCIDENCE SELECTIVE BAND PASS FILTER FOR IMPLANTABLE CHEMICAL SENSOR	04.03.2015; EP2841928	SENSEONICS INC	COLVIN ARTHUR E	Apparatuses and methods for limiting the angle of incidence (AOI) of light reaching a dichroic filter. The apparatus may include an AOI filter element and the dichroic filter. The apparatus may be a sensor and may include a photodetector. The dichroic filter may be configured to prevent light having a wavelength outside a band pass region from reaching the photodetector and to pass light having a wavelength within the band pass. Physical limitations of the dichroic filter may preclude the dichroic filter from preventing high AOI light having a wavelength outside a band pass region from reaching the photodetector. The AOI filter element may be configured to prevent light having a high AOI from reaching the dichroic band pass filter and to propagate light having a low AOI to the dichroic band pass filter. The AOI filter element may be a fiber optic bundle comprising a plurality of optical fibers.
CHEMICAL SENSOR, METHOD OF PRODUCING CHEMICAL SENSOR, AND CHEMICAL DETECTION APPARATUS	19.02.2015; US20150050187	Sony Corporation	Mogi Hideaki	[Object] To provide a chemical sensor capable of detecting light emitted from a detection target object efficiently, a method of producing the chemical sensor, and a chemical detection apparatus. [Solving Means] A chemical sensor according to the present technology includes a substrate and a lens layer. On the substrate, at least one light detection unit is formed. The lens layer is laminated on the substrate and has optical transparency, and a lens structure is formed on a surface of the lens layer opposite to the substrate in a concave shape toward a lamination direction.
INTEGRATED METAL OXIDE CHEMICAL SENSOR	05.02.2015; US20150033827	Sensirion AG	BURGI Lukas	A chemical sensor (**10**) is described with at least one layer of a metal oxide (**11**) arranged between two current injecting electrodes (**16,16**) with the length (L) of the layer of a metal oxide between the current injecting electrodes being less than 50 microns and one or a pair of voltage sensing electrodes (**17**) connected to the layer of a metal oxide (**11**) with the electrodes (**16,16',17**) forming a 3- or 4-terminal arrangement for determining the resistance changes of layer material (**11**) excluding series resistances such as contact resistances close to or at at least one of the current injecting electrodes (**16**) from the resistance measurement.

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

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