TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

08th May 2015

1. OPTICS AND NANOTECHNOLOGY CREATE COMPACT GAS SENSOR

Gas sensors are widely used in applications such as industrial safety and hygiene, environmental (including stack gas) monitoring, automotive emissions monitoring,automotive cabin air quality monitoring, indoor air quality monitoring, health care (for example, anesthesia monitoring), residential (e.g., carbon monoxide alarms), homeland security, food and beverage, and so on. Key types of gas sensing technologies in the marketplace include electrochemical, tin or metal oxide semiconductor, catalytic bead, and infrared and other optical technologies.

In gas sensors, there are ongoing, key needs for improved detection sensitivity, selectivity to the target gas of interest, and response time. There are, moreover, key requirements for lower-cost and more compact gas sensors. Such capabilities enable gas sensors to have expanded applications.

Making advancements in these areas, researchers at the US-based Oregon State University, have carried out a collaborative research with researchers at the US Department of Energy (DOE)'s National Energy Technology Laboratory (NETL). Both research teams have together developed an innovative, cost-efficient, sensitive gas sensor that combines optical technology and nanocomposite thin films. The technology leverages the effectiveness of optical technology in detecting trace-level gases; and in addition overcomes the need to use expensive, cumbersome laboratory devices. The researchers use an optical approach that can allow for small, portable, and inexpensive sensing solutions. The system has employed plasmonic nanocrystals that can concentrate light wave and enhance sensitivity.

The approach is combined with a metal-organic framework of thin films that can quickly adsorb gases within material pores, and be recycled by simple

vacuum processes. After the thin film captures the gas molecules near the surface, the plasmonic materials, working in the near-infrared range help magnify the signal and can precisely analyze the presence and amount of various gases. Operation in the near infrared range, combined with the use of plasmonic nanoctrystals, can allow for a significant (order of magnitude) gain in sensitivity.

The sensor's benefits of speed, accuracy, portability, and cost-effectiveness can be well-suited for varied applications in the food, industrial, and other sectors . The sensor, which is especially suited to detect carbon dioxide, could be used in the food sector, which uses carbon dioxide in the storage of fruits and vegetables) and in industrial applications or systems designed to store carbon dioxide underground for reduction of greenhouse gas emissions. The technology could also find application in other areas, such as border security, health care, optimization of automotive engines, or natural gas leak prevention.

Oregon State University has filed for a patent on the invention, and the university researchers are seeking industrial collaborators to further enhance and help commercialize the system.

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2. MEMS VOC SENSOR FOR HOME MONITORING

Volatile organic compounds (VOCs) are chemicals that have a high vapor pressure, and readily evaporate into the air, at room temperature. Concentrations of such chemicals can be considerably (up to at least 10 times) higher indoors than outdoors. Numerous products or substances contain and emit VOCs, such as paints and varnishes, benzene, butane, hexane, toluene, xylene, building materials, pesticides, fuel oil, cooking oil, cleaning supplies, carpeting, wallpaper, growing mold, printers or copiers, cosmetics, pressed wood furniture, vinyl flooring, cleaning supplies, and so on. Many VOCs cannot be detected by smell. VOCs may trigger or worsen asthma attacks, and have been linked to other harmful health effects; for example, headaches, nausea, and damage to the liver, kidneys, or central nervous system . Particularly

dangerous VOCs emitted from certain products in homes include formalehyde, benzene, and phenol.

There are needs for improvements in VOC sensing, including more convenient and compact devices that do not require lab analysis.

Manifesting opportunities for enhancements in VOC sensors for home monitoring, Austria-based ams AG, is now supplying MEMS gas sensors for VOC detection for use in Withings' innovative home monitoring system. The compact, power-efficient AS-MLV-P2 VOC sensor is designed to be highly sensitive to VOCs and to provide precisely varying resistance in response to changing levels of pollutants in indoor settings.

The VOC sensor can measure the ambient concentrations of a wide range of reducing gases associated with poor air quality, such as alcohols, aldehydes, ketones, organic acids, amines, and aliphatic and aromatic hydrocarbons. In the Home app, the sensor's measurements are converted to an air-quality rating and to a measurement of VOC concentration.

Based on a combination of thick-film, thin-film and other proprietary techniques, the VIC sensor component has an efficient design. The heater and inter-digital electrode structures are located on an LPCVD (low pressure chemical vapor deposition) silicon nitride membrane that has a thickness of only about one micrometer, facilitating low power consumption. The VOC sensor is geared toward providing the size, accuracy, reliability, and low power consumption for monitoring air quality in smart home or Internet of Things devices.

The sensor's ability to provide accurate VOC detection stems from the implementation of proprietary MEMS and metal oxide semiconductor (MOS) technology developed by ams. Available in a surface-mount package, is geared for long-term stability, while consuming low power (typically 34mW in continuous operation).

In the home monitoring system, the VOC sensor is combined with a 5 Mpixel video camera, dual microphones, temperature and humidity sensors, and Wi-FI® and Blutooth® smart radios, enabling users to see, hear, or smell the inside of the home remotely utilizing a smart phone or tablet app.

The home monitoring unit sends notifications to the user's phone or tablet when the concentration of VOCs exceeds pre-set thresholds, so the user

can take corrective action, such as opening a window, activating an air cleaner or increasing ventilation system's fan speed.

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3. ADVANCEMENTS IN SENSOR POWER CONSERVATION

As sensors move toward becoming more ubiquitous or persistent and find ever-expanding opportunities to be used in large scale wireless networks and to monitor numerous devices simultaneously, there are intensifying needs to reduce sensor power consumption. Sensing devices with active electronics that require a power supply and electrically electron flow constantly consume power. A great deal of that power, and time, can end up being used to process extraneous, irrelevant data.

The power consumption requirements can limit the sensor's lifetime when powered by batteries. In military applications, the need to redeploy power-diminished sensors can render a soldier more exposed to danger in addition to being costly and time consuming.

US Defense Advanced Research Projects Agency (DARPA) has launched the Near Zero Power RF and Sensor Operations (N-ZERO) program to surmount the power limits for persistent sensing through the development of wireless, event-driven sensing capabilities that would enable sensors (including physical and electromagnetic, as well as other types of sensing devices) to remain dormant yet aware until wakened by an event of interest. The intent is to develop underlying technologies to continuously and passively monitor the environment and to activate an electronic circuit only when a specific signature is detected, such as the presence of a certain type of vehicle or radio communications protocol. The energy in the signal signatures will be used to detect and identify events that merit attention while rejecting noise and interference.

The wait for a specific event or activity limits the mission life and depletes the battery energy of the essential electronics, noted Troy Olsson, DARPA program manager. The N-Zero will focus on enabling energy-efficient, wireless, ubiquitous sensing to for enhanced warfighter safety. The aim is to use the correct signal itself to awaken the sensor. This capability would improve

the effectiveness of the sensors and enhance the warfighter's situational awareness by considerably reducing false alarms.

The N-ZERO program reflects DARPA's desire to render the power draw of sensors remarkably more efficient when they are not sensing something of interest. The aim is to use less than 10 nanowatts (nW) during the sensor's asleep-yet-aware phase: an energy reduction approximately equivalent to the self-discharge (battery discharge during storage) of a typical watch battery, and at least 1,000-fold less than state-of-the-art sensors. The N-ZERO seeks to extend unattended sensor lifetime from weeks to years, while reducing maintenance costs and the need for redeployments. N-ZERO could also reduce battery size for a typical ground-based sensor by a factor of 20 or more while retaining its current operational lifetime.

Initially, the N-ZERO program will focus on improved capabilities for sensors used for RF (radio frequency), electromagnetic, acoustic, and inertial detection and analysis. The program, if successful, can have opportunities to improve the efficiency of the Internet of Things (IoT) and render the IoT more effective and practicable in a wide range of environments and applications, as the sensors would be able to operate without a constant local power source or a constant need for battery recharging or replacement.

DARPA seeks proposals for N-ZERO. Information about the Broad Agency Announcement can be found at http://go.usa.gov/hN3T.

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4. RECENT PATENTS IN THE FIELD OF PIEZOELECTRIC ENERGY HARVESTING

Battery-powered devices have the inherent challenge of regular maintenance, battery disposal, and power consumption issues, which have impeded the growth of various technologies, such as ubiquitous monitoring and wireless sensor networks (WSN). Energy harvesting (EH) can prolong the use of battery-powered devices, and in the case of lower power requirements, could become the sole power source.

Energy harvesting technology makes use of existing ambient energy sources to power devices. This energy can be used for low-power applications and stored in a battery for future use. Among the energy harvesting technologies piezoelectric harvesting is an important technique for harvesting energy from vibrations. The piezoelectric effect converts mechanical strain into usable electrical energy. The applications for harvesting vibration energy can depend on the amount of vibrations in an environment and the periodicity or availability of the vibrations.

Sensors and WSNs powered by energy harvesters are more cost-effective compared to battery-only power sources. The costs associated with maintenance and disposal of batteries can be avoided; environmental pollution due to battery leakage can be prevented. EH devices enable sensors to be located in remote or sensitive areas that require maintenance-free power at low voltages, depending on the field of application. EH devices can provide sufficient maintenance-free power for WSN applicatio

EH will have impact on various industries in the near to medium term, such as building or home automation,industrial equipment monitoring, process monitoring, consumer electronics, automotive and transportation, utilities, and so on. Proliferation of energy harvesting devices is expected with standardization and increased power density of the harvesters. EH will find opportunities in other areas as the penetration of autonomous sensor nodes becomes higher.

Companies from diverse industries have filed for patents related to energy harvesting, which is an indication of its vast application scope. In the last four years, the most number of patents have been published in United States.

A recent patent in energy harvesting (US20150091415), assigned to Sorin CRM SAS, pertains to an autonomous intracorporeal capsule containing an energy harvesting module with an energy harvesting piezoelectric transducer. A mcehanical stress is produced under the effect of pressure variations.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
AUTONOMOUS INTRACORPOREAL CAPSULE WITH ENERGY HARVESTING BY PIEZOELECTRIC TRANSDUCER	02.04.2015; US20150091415	SORIN CRM SAS	Martin Deterre	An autonomous intracorporeal capsule comprises a body containing electronic circuits and an energy harvesting module. The energy harvesting module comprises a moveable surface on the body of the capsule, subjected to pressure variations and to produce a mechanical stress under the effect of the pressure variations, and a transducer comprising a deformable piezoelectric component configured as a beam adapted to be forced to bend. The piezoelectric component has a recessed end integral with the capsule and a free end. A mechanical connection couples the free end of the piezoelectric component to the actuator. The mechanical connection may provide a degree of freedom in rotation between a main direction of the beam and the direction of application of the mechanical stress.
PIEZOELECTRIC ENERGY HARVESTING	19.03.2015; WO/2015/036869	MEGGITT A/S	ZAWADA, Tomasz	An energy harvesting unit comprising: a package formed by a base and a lid, the package including a sealed interior volume and an exterior; a ledge formed in the sealed interior volume with a first cavity above and a second cavity below the ledge; a plurality of inner electrical contacts formed on the ledge; a plurality of outer electrical contacts formed on the exterior of the package wherein the outer electrical contacts are electrically connected to the inner electrical contacts through the package; and, a piezoelectric member in electrical communication with the inner electrical contacts and coupled to the ledge on a first side of the package and spanning across the cavity and coupled to the ledge on an opposite side of the package.
PIEZOELECTRIC HARVESTING SYSTEM USING COMPRESSION FORCE	19.02.2015; WO/2015/023015	SEEDENERTECH CO., LTD.	SUNG, Tae Hyun	A piezoelectric harvesting system using compression force, according to one embodiment of the present invention, comprises: a piezoelectric body comprising a piezoelectric material; and a fixed body to which the piezoelectric body is adhered, wherein the piezoelectric body is adhered to one surface of the fixed body that is compressed, so that compression force is also applied to the piezoelectric body when compression force is applied to the fixed body, thereby generating electric energy. According to one embodiment of the present invention, compression force is applied by an external force from a load or a hit, which is in turn used for generating electric energy.
PIEZOELECTRIC HARVESTING SYSTEM USING REPULSION FORCE	19.02.2015; WO/2015/023018	SEEDENERTECH CO., LTD.	SUNG, Tae Hyun	A piezoelectric harvesting system using repulsion force, according to one embodiment of the present invention, comprises: a piezoelectric body comprising a piezoelectric material; a fixed portion to at least one surface of which the piezoelectric body is adhered; a support portion for supporting one side of the fixed portion; and a repulsion force-providing portion for providing repulsion force to the fixed portion, so that the piezoelectric body generates electric energy when the fixed portion is deformed due to application of external force and then recovered. According to one embodiment of the present invention, additional shock is applied to the fixed portion to which the piezoelectric body is adhered when recovering after being deformed, thereby increasing the amount of electric energy generated due to the deformation of the piezoelectric body.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
PIEZOELECTRIC TRANSDUCER FOR AN ENERGY-HARVESTING SYSTEM	05.02.2015; US20150035409	STMicroelectronics S.r.l.	Procopio Francesco	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.
Piecewise Piezoelectric Energy Harvester	15.01.2015; US 20150015114	TEXAS INSTRUMENTS INCORPORATED	Hall James	A piezoelectric energy harvester device has a cantilevered structure with a rectangular proof mass portion defined by holes through a substrate along three sides of a proof mass portion and supported by a thinned hinge portion for free pivotal movement relative to an anchor portion. Elongated strips of piezoelectric energy harvesting units are formed in side-by-side spaced positions on the hinge portion and aligned parallel or perpendicular to a stress direction. Multiplexing electronics coupled to contact pads on the anchor portion selectively connects different strip combinations to power management circuitry, responsive to variations in vibration magnitude or modes.
SELF-POWERED PIEZOELECTRIC ENERGY HARVESTING MICROSYSTEM	08.01.2015; US20150008792	TEXAS INSTRUMENTS INCORPORATED	Gong Cuiling	A self-powered piezoelectric energy harvesting microsystem device has CMOS integrated circuit elements, contacts and interconnections formed at a proof mass portion of a die region of a semiconductor wafer. Piezoelectric energy harvesting unit components connected to the integrated circuit elements are formed at a thinned beam portion of the die region that connects the proof mass portion for vibration relative to a surrounding anchor frame portion. A battery provided on the proof mass portion connects to the integrated circuit elements. In a cantilever architectural example, the battery is advantageously located at a distal end of the proof mass portion, opposite the joinder with frame portion via the beam portion.

Exhibit 1 lists some of the patents related to piezoelectric energy harvesting.

Picture Credit: Frost & Sullivan

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