# TECHNICAL INSIGHTS

## SENSOR

## TECHNOLOGY ALERT

13th February 2015

## 1. SENSORS BASED ON NANOTECHNOLOGY TO DETECT HAZARDOUS CHEMICALS

It is vital to detect tiny molecules while detecting hazardous chemicals. There are various devices available in the market to detect hazardous chemicals. These devices are deployed at airports, railway stations, bus stations and many other places to detect hazardous chemicals in the early stages. However, these devices are bulky, require experts to interpret the results and are expensive. In addition, these devices are not able to detect extremely tiny or volatile explosives in the air. There is a need for an inexpensive, mobile sensor which can detect tiny molecules in real time and perform its own mathematical analysis to figure out the respective chemicals. In addition the device should be easy to use and capable of detecting a variety of chemicals.

To address the above challenge, researchers from Tel Aviv University and Israel-based company, Tracense, have developed a nano-sized chemical sensor. Researchers at the University and Tracense are calling it Tess. Tess is inspired by nanotechnology to detect various explosives which are very difficult to detect by the current technology.

Tess is deployed with hundreds of super sensitive sensor and nano-sized transistors. Transistors employed by Tess are extremely sensitive to chemicals. When the surface of the device comes in the contact with a single molecule of the hazardous chemicals or explosives, there is a change in the electrical conductance of the sensor. Tess binds with the molecule and starts accurate and rapid mathematical analysis of the material. While analyzing the material, Tess is also capable of differentiating hazardous and non-hazardous materials. Tess is capable of detecting hazardous materials in the air with the concentration of a few

 

molecules per 1000 trillion. Tess can also detect small molecular species in the air with the concentration of parts per quadrillion. Tess is five times more sensitive to hazardous chemicals than existing technologies and it is capable of detecting hazardous materials in real time.

Once Tess is successfully commercialized, it is expected to detect improvised explosives which are used by suicide bombers, such as TATP (triacetone triperoxide) and HMTD (hexamethylene triperoxide diamine). These two explosives are home made and it is very difficult to detect these chemicals with existing technologies. Other chemicals which can be detected by Tess are TNT (trinitrotoluene), RDX (cyclotrimethylenetrinitramine), and HMX (Octogen); these chemicals are used in military and commercial blasting applications. Researchers at Tel Aviv University are extensively conducting tests on the prototype of the device to detect different chemicals.

The project was funded by Tracense, a privately held technology company in Israel. Since 2007, Tracense has invested $10 million for the development of Tess. The researchers are currently identifying different chemicals that can be detected with the help of Tess. Tess is expected to be commercialized by the end of 2015. Once Tess is commercialized, it is expected to get a good response from military personnel to detect blasting chemicals.

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## 2. PRINTED AND FLEXIBLE SENSOR TO DETECT ADVANCED EXPLOSIVE AND CHEMICAL THREATS

There are numerous chemical desktop detectors available in the market, which are able to detect various types of chemicals and differentiate between them. This detector consumes a huge amount of power and it is bulky in size as well as expensive. There is a need for a device that is able to detect various chemicals. In addition, the device should be small in size, cost effective, wireless and ensure low power consumption. The device should be easy to use and enable deployment in various places.

To address the above challenge, researchers from GE Global Research have developed a new sensor based on radio-frequency identification (RFID) technology to detect chemicals, such as explosives and oxidizers at very low concentrations.

The researchers at GE Global Research have developed a device with the help of a thin film flexible substrate and roll to roll fabrication technique. The device is made up of two parts; one of them is an RFID sensor tag and the other is cellphone sized handheld tag reader. The tag is composed of a flat coiled antenna which is attached to the microchip. The antenna is used to harvest the power from the reader. When the device detects the molecules or particles of explosives or oxidizers that are used to develop a bomb, it sends signals to the reader through the antenna. Once the reader comes to know about the explosives, officials in airports, seaports or railway stations can be alerted. As this process helps to detect hazardous chemicals accurately, the safety of cargo that passes through ports can be ensured. The device is 300 times smaller than devices available in the market and consumes 100 times less power.

Once the sensor is successfully commercialized, it will be deployed for real-time measurement to detect biological and chemical properties in healthcare and agriculture as well as the natural resources and consumer sectors. The device will be used to detect passive gas leaks, bacterial contamination, and electrical insulation degradation. The device will be used to detect chemical threats and it will be deployed in cargo containers used in airports, seaports and railway centers. The sensor is very easy to manufacture and the total ownership cost per sensor will depend on the performance specs and fabrication volume.

The project was supported by the Technical Support Working Group (TSWG), a US Interagency program for research and development into counter-terrorism, Quantum Magnetics, a subsidiary of Morpho Detection, and KemSENSE, a subsidiary of Vener8 Technologies. The project was partly funded by the above organizations and research and development agencies. The researchers are currently testing the device to identify the various gases. The sensor is expected to be commercialized in one to two years' time. Once the sensor is successfully commercialized, it is expected to get a good response from the shipping industry.

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## 3. WIRELESS SENSING DEVICE TO DETECT CHEMICALS

Chemical sensing technology can be used in various applications, such as food, pharmaceuticals, chemical processing, residential or commercial applications (such as carbon monoxide detection), biomedical and automotive, among other applications. The sensors available in the market are expensive, bulky and communication range capabilities are too low to detect harmful chemicals. There is a need for a device that has long range capabilities to sense chemicals and send the trigger alarm to the user. In addition, the device should be small in size, cost effective and easy to use and enable deployment at various places.

To address the above challenge, researchers from Georgia Tech Research Institute have developed a small electronic sensing device. This device will be able to alert the user wirelessly if chemical vapors are present in the atmosphere.

Researchers at Georgia Tech Research Institute have developed the sensing device based on carbon nanotubes and other nano materials to detect some specific chemicals. The device is integrated with an array of sensors, and radio-frequency identification (RFID) and nanotechnology capabilities. The researchers have used aerosol jet printing to print the circuit on a paper substrate. The device is based on programmable digital technology and thus RFID components provide high reliability, security, and good range; in addition, the device is small in size. The device uses 5.8 GHz of radio frequency, which is one of the band frequencies reserved for medical, scientific and industrial purposes. While working on this frequency, the device will provide additional advantages, such as increased resistance to interference from materials, such as metals and providing accurate reading about hazardous chemicals and explosives. In addition, the device will also provide greater security due to digital techniques that will prevent unauthorized access to the wireless data stream. As the nature of reading will be digital, it will help the user to easily interpret data on chemical concentrations. In addition, it will also increase the communication range capability of the device.

Once the project is successfully completed, it will have opportunities to be deployed indoors as well as outdoors. The device will be able to detect harmful gases and explosives. The wireless sensor would be valuable to detect and understand air pollution. The researchers have been able to detect nitrogen and ammonia gas. The device will also be used to detect food spoilage and will also detect telltale chemicals in healthcare. The device can find application in various sectors, such as military, environmental, commercial, and healthcare among

others. In the future, researchers can employ a liquid crystal polymer as the substrate. In addition, the other nano materials that can be used in the future to develop the wireless electronic sensing device to detect hazardous chemicals are graphene, carbon nanotubes and molybdenum disulfide. The researchers are currently working on enabling different applications with the help of wireless electronic sensing devices.

The project was self-funded by Georgia Tech Research Institute. The researchers are currently working on developing the pattern recognition software which will further help to support the functioning of the sensor array. The researchers are also working on testing the device and identifying different chemicals that can be detected with the help of the device. The device is expected to be commercialized in one to two years' time. Once the device is successfully commercialized, it is expected to get a good response from the military and defense sectors for detecting numerous hazardous chemicals in busy environments, such as airports.

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## 4. RECENT PATENTS IN THE FIELD OF CHEMICAL SENSORS

A device that transforms chemical information into an analytically useful signal is called a chemical sensor. The chemical information ranges from concentration of a specific sample constituent to total composition analysis. Chemical sensors are vital for analyzing chemical composition in industries such as automotive, industrial, medical and environmental.

From 1969 to 2015, approximately 330029 patents have been registered under chemical sensing (approximately 25 patents have been registered in 2015). Of these, approximately 1862 patents were registered in Africa which includes Egypt, Kenya, Morocco, and South Africa; approximately 202351 patents were registered by America which includes USA and Canada; approximately 66312 patents were registered by Asia-Europe, including Bahrain, China, Eurasian Patent office, Estonia, European Patent office, Israel, Japan, Jordan, Portugal, Russian Federation, Singapore, Spain, Republic of Korea, Vietnam, and United Arab

 

Emirates and many more have been registered under chemical sensing from different parts of the world.

While patents related to chemical sensors can be traced back to 1969, the real surge in patenting activity has happened in the past 5 years. In terms of regional publication where patent protection is most frequent for this technology, America leads the count followed by Europe and Asia. The intensity for the development of chemical sensors in America is high. The development of chemical sensors is largely research-based, with a relatively large portion of academic participation.

Based on current trends in patent publication, chemical sensors are now finding applications in diverse range of areas. There is a strong interest in detecting chemicals and explosives. The US Department of Homeland Security is supporting key programs in chemical sensing such as detecting hazardous chemical vapors in critical infrastructure. Growing economies in Asia such as India are keenly interested in boosting their security by increasing their chemical detection capabilities.

Some of the participants investing in chemical sensing R&D include Sensirion AG., Isuzu Motors Limited, Sony Corporation, IMEC, Hitachi Ltd., East China Normal University, NGK and Roche, Bosch, Abbott Laboratories, and Bayer.

| Title | Publication Date/Publication Number | Assignee | Inventor | Abstract |
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| CHEMICAL SENSOR, CHEMICAL SENSOR MANUFACTURING METHOD, AND CHEMICAL MATERIAL DETECTING APPARATUS | 28.01.2015; EP2829865 | SONY CORP | 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. |
| Detecting Chemical And Biological Agents Using Textile-Based Sensors | 01.01.2015; US20150004593 | SRC, INC. | Lowe Adam J. | Methods and systems for detecting chemical and biological agents using oligonucleotide aptamers. A sensor includes a detection aptamer that has a binding domain for the chemical or biological agent, and is bound to fibers of a textile such as a patch or article of clothing. The detection aptamer can be stabilized and enhanced through a stabilization agent such as trehalose or through binding to a nanoparticle which is then bound to the fiber. Binding of the chemical and |

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| | | | | biological agent of interest to the detection aptamer can be reported to the user or wearer of the textile in a variety of ways, including visually and electrically. |
| CHEMICAL SENSOR ARRAY HAVING MULTIPLE SENSORS PER WELL | 18.12.2014; WO/2014/200775 | LIFE TECHNOLOGIES CORPORATION | ROTHBERG, Jonathan | The device includes a material defining a reaction region. The device includes a plurality of chemically-sensitive field effect transistors (chemFET) each having a common floating gate (370) in communication with the reaction region. The device also includes a circuit to obtain respective output signals from the chemically- sensitive field effect transistors indicating an analyte within the reaction region. |
| COMPOSITION HAVING ULTRA-HIGH SENSITIVITY AND HIGH SELECTIVITY FOR DETECTING COPPER ION AND FLUORESCENT CHEMICAL SENSOR | 18.12.2014; WO/2014/200164 | KOREA BASIC SCIENCE INSTITUTE | PARK, Kyeong Soon | The present invention relates to a composition having ultra-high sensitivity and high selectivity for detecting a copper ion; a fluorescent chemical sensor comprising the same; a method for manufacturing the same; a method for selectively detecting a copper ion; a method for screening a copper ion chelating agent; and a method for confirming a chelating effect of a copper ion chelating agent. The present invention is applicable in detecting a copper ion in water from a river, lake, ocean, or the like, and bio-samples, such as plasma, serum, and urine, and is applicable in high-rate mass-screening for evaluating the effect of the existing copper ion chelating agent and developing novel copper ion chelating agents. Further, the copper ion can be qualitatively and quantitatively detected in the serum in cells and in the body, and the present invention is applicable as a disease diagnosing kit. |
| Integrated metal oxide chemical sensor | 03.12.2014; EP2808675 | SENSIRION AG | VON WALDKIRCH MARC | A chemical sensor assembly for measuring the concentration of a gas analyte in a sample of air is described having on a common substrate (14) a first and a second sensor (10,30) each with at least one layer (11) of a metal oxide arranged between two electrodes (16) with the first and second sensor (10,30) having essentially identical dimensions and structure and with the second sensor (30) including an additional barrier (31, 11) for the gas analyte so that the second sensor (30) is essentially insensitive to the gas analyte and can be a reference sensor (30) for the first sensor (10). |
| Nanoscale Spintronic Chemical Sensor | 20.11.2014; US20140342463 | UNIVERSITY OF SOUTH CAROLINA | Crawford Thomas M. | 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. |

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| OPTICAL FLUORESCENCE-BASED CHEMICAL AND BIOCHEMICAL SENSORS AND METHODS FOR FABRICATING SUCH SENSORS | 30.10.2014; US20140319378 | IMEC | Van Steenberge Geert | An optical fluorescence-based sensor comprising at least one sensing element is disclosed. In one aspect, the at least one sensing element comprises a waveguide comprising a waveguide core, a light source optically coupled to an input part of the waveguide core, and a photodetector optically coupled to an output part of the waveguide core, the waveguide core being made of a material comprising a mixture of an optical material and a fluorescent dye. |

**Exhibit 1 lists some of the patents related to chemical sensing.**

*Picture Credit: Frost & Sullivan*

**Back to TOC**