TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

17th July 2015

1. NOVEL METHOD TO MANUFACTURE COST-EFFECTIVE MAGNETIC SENSORS

Magnetic field sensors; which sense the strength or direction of magnetic fields; provide information about orientation, direction, and navigation in relation to the Earth's magnetic fields. Magnetic field sensors are finding expanding opportunities to provide such information in key applications, such as in pedestrian navigation in smart phones, vehicle or aircraft navigation.

Magnetic field sensors also provide heading information in compasses; and magnetic field sensors that provide heading information by determining orientation relative to the South and North pole field direction are used in electronic compasses to complement global position of satellite receivers.

One-dimensional (1D) magnetic field sensors, which are sensitive to only one component of the magnetic field vector, are less sensitive to environmental conditions and less accurate than a two-dimensional (2D) sensor.

There is potential for 2D magnetic sensors, which would be highly sensitive to environmental conditions, and to discover new production methods to reduce production time and manufacturing costs of these sensors.

To address the above needs, researchers from the Fraunhofer Institute for Electronic Nano Systems (ENAS) have deduced a new method to manufacture cost-effective 2D magnetic sensors for integration in smartphones. A conventional one-dimensional magnetic field sensor has required two microelectronic half bridges whose magnetic fields point in opposite directions. Since the basic materials specify a direction of magnetization, the two different pieces of material need to be joined, which can be a relatively complex, expensive task. 2D magnetic field sensors have required two half bridges or four pieces of material. This process is expensive and takes a long time to achieve the final product. In comparison, ENAS researchers used one piece of material to produce one full microelectronics bridge. To produce a 2D sensor with one piece, the researchers separated a layer of material off a wafer, used laser treatment to etch the desired structure out, and adjusted the magnetic field according to the need. The 2D magnetic sensor is less than a square millimeter in size. The small size and reduced cost of production will help in increasing rate of adoption of this sensor.

Once the sensor is successfully commercialized, it is expected to be first used in mobile phones to provide accurate navigational data to users. The small chip of the magnetic sensor can also be used in the magnetic field cameras to achieve high resolution recording of magnetic data with minimal interference. In addition, the sensor can be used in electronic gear levers on the steering wheel or in the central console of new vehicles. The sensor will also have applications in medical diagnostics--it can be used to trace tropical diseases and other viruses and bacteria.

The project was self-funded by ENAS. The researchers are currently working on identifying various different applications of cost- effective magnetic sensors. The novel optimized manufacturing process will help to cut the total cost of production to half that of the conventional process. In addition, the total time taken for the production cycle will be reduced by 50%. These two parameters will help in gaining traction and boosting sales of this magnetic sensor.

Details: Dr. Olaf Ueberschär, Group Manager, Fraunhofer Institute for Electronic Nano Systems ENAS, Technologie-Campus 3, 09126 Chemnitz, Germany. Phone: +49-371-45001-0. E-mail: Olaf.Ueberschaer@enas.fraunhofer. URL: www.fraunhofer.de

2. WEARABLE ULTRA-SENSITIVE STRAIN SENSORS

Wearable sensors are gaining traction in various different industries such as healthcare, consumer electronics, and many more. In addition, robots will be more widely used across various different industries. To achieve optimized performance, it is highly important that the user is able to communicate with the robot more efficiently and realistically. Robots should be able to understand users' feelings and should be able to respond with a computerized version of empathy. There are many ongoing research initiatives to help robots understand human feelings. At present, various universities are working on visual sensors, which can identify when a user smiles. But these systems are highly complex, expensive, and not efficient enough to detect all eye movements. There is a need for a cost efficient, easy-to-use, and highly sensitive system to detect facial expressions of human beings efficiently and effectively.

To address the above mentioned challenges, researchers from SKKU Advanced Institute of Nanotechnology (SAINT) have developed an ultrasensitive, transparent, wearable, and stretchable strain sensor for a human-machine interface. The cost efficient sensor can identify slight changes in facial expressions--from sadness to joy, boredom to surprise, and so on--and even a change in the gaze. The sensor is comprised of two types of electrically conductive elastomers--polyethylenedioxythiophene and polystyrenesulfonate (PEDOT: PSS) and polyurethane (PU)--and carbon nanotubes. The stretchable sensor is developed by layering a piezoresistive nano hybrid film of single-wall carbon nanotubes (SWCNTs) on a conductive elastomeric composite. The sensor is attached to human skin to detect small strains, which are induced by emotional expressions such as laughing and crying, as well as eye movement.

At present, researchers are deducing the technique to feed the information from the strain sensor to the robot. This sensor will help robots to identify facial expressions, such as smiling, crying, eye rolling, brow furrowing, frowning, and so on. Other than robotics, the wearable sensor has the potential to be deployed in healthcare and medical industry. The wearable sensor can enable several applications in healthcare and medical sectors, such as monitoring breathing, heartbeat, or detecting if a person is facing difficulty in swallowing. The sensor is ultra-sensitive and accurate and will enable users to monitor their health conditions and take appropriate action on a timely basis.

The project was funded by National Research Foundation of Korea. Researchers are currently working on identifying different applications for their strain sensor. Once the sensor is successfully commercialized and the system is fully developed, it is expected to get a good response from robot developers. Its low cost and ultra-sensitivity would help the sensor to gain traction among robot developers.

Details: Nae-Eung Lee, Professor, Department of Materials Science and Engineering, SKKU Advanced Institute of Nanotechnology (SAINT) and Samsung Advanced Institute for Health Sciences and Technology (SAIHST), Sungkyunkwan University (SKKU, Suwon, Kyunggi-do 440-746, Korea. Phone: 031-290-7398. E-mail: nelee@skku.edu. URL: http://www.useoul.edu/

3. ULTRA-FAST LINE SCAN SENSORS

Accurate image reproduction in security printing is very important. To improve security and identify counterfeiters, bank notes are equipped with special security features such as holograms with tilt effects. But conventional image sensors are limited in this regard. The scanning principle of these sensors is not adequate enough to check quality in real-time during the production process. There is a need for a cost-effective, highly efficient, and fast scanning sensor, which can detect false bank notes in real time.

To address the above challenge, researchers from the Fraunhofer Institute for Microelectronic Circuits and Systems have developed an ultra-fast line scan sensor, which works like a scanner to identify fake notes and bills. Researchers have developed a system to record the image from the scan sensor and compare it with the desired image to efficiently and effectively identify banknotes with faulty safety features.

The sensor is twice as fast as sensors that are currently available in the market. The sensor scans the currency line by line. For each column, the researchers have integrated a chip to readout the chain of pixels individually. In addition, for each column, three different colors--red, green, and blue--are recorded, which helps the sensor to reproduce high-quality color images. Scanning the currency per column helps in detecting objects from different perspectives and in analyzing 3D holograms.

In addition, a camera is employed to capture up to 200,000 color images per second. The color recorded images are further compared with the desired images using software. The software helps to identify banknotes with faulty features.

Once the project is successfully commercialized, it will be used by the Central Bank to print currency notes. In addition, it will be employed by other banks to identify fake notes. The architecture of the sensor system opens up several different applications. The sensor can also be used to identify shredded material according to color information. The ultrafast line scan sensor is also capable of analyzing 3D surfaces, which would enable using it for quality control of materials in industrial production facilities.

The project was supported by the Austrian Institute of Technology (AIT). The researchers are currently working on identifying different applications that can be enabled with the help of the scanning sensors. The line scan sensor is expected to be commercialized by AIT by the end of 2015. Once the system is successfully commercialized, it will be adopted by banks in Germany and Austria. The sensor system is expected to gain lot of traction from other countries and banks.

Details: Werner Brockherde, Head of Department, Optical Sensor System, Fraunhofer Institute for Microelectronic Circuits and Systems IMS, Finkenstraße 6147057, Duisburg, Germany. Phone: +49-0-203/3783-230. E-mail: Werner.Brockherde@ims.fraunhofer.de. URL: www.ims.fraunhofer.de

4. RECENT PATENTS IN THE FIELD OF NANOSENSORS

Nanosensors are sensors that are very minute and built on the nanoscale using nanocomponents or nanomaterials. Nanosensors are capable of detecting stimuli such as biological or chemical substances and physical stimuli such as pressure at the nanoscale with dimensions on the order of a billionth of a meter. The smallest functional organization of a nanosensor in at least one direction is at least in the nanoscale (one billionth of a meter).

Nanosensors are built with the help of top-down lithography, bottom-up assembly, molecular self-assembly, or using carbon nanotubes (CNTs). Nanosensors can offer key benefits, such as superior sensitivity and specificity, ultra-small size, ultra-low power, in diverse application fields, including chemical sensing or biosensing. Nanosensors have the capability to converge with technologies such as wireless sensor networks and energy harvesting.

China publishes the most number of patents in the nanosensors domain, followed by Republic of Korea. This indicates a strong focus on nanosensors and nanotechnology in the APAC region. Research institutes and universities are leading in publishing patents in this field. Nanotechnology research has been quite strong in North America, in areas such as chemical and biological agent detection. European universities and organizations are actively involved in developing and commercializing nanotechnology-based sensing devices. Among them, the Fraunhofer Institutes are conducting research on various nanosensor technologies.

The key applications benefiting nanosensors include chemical and gas detection with the help of technologies such as Raman spectroscopy and electronic noses; biosensing; environmental monitoring and protection; and CBRNE (chemical, biological, radiological, nuclear, explosives) detection.

Universities and research organizations are major entities responsible for initially developing and advancing nanosensor technologies. Key stakeholders include Zhejiang University, Tianjin University, Jilin University, Korea Institute of Science and Technology.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Implantable nanosensor	24.06.2015; EP2885627	Hewlett Packard Development Co.	Barcelo Steven J	An implantable nanosensor includes a stent to be implanted inside a fluid conduit. The stent has a well in a surface of the stent. The implantable nanosensor further includes a nanoscale-patterned sensing substrate disposed in the well. The nanoscale-patterned sensing substrate is to produce an optical scattering response signal indicative of a presence of an analyte in a fluid carried by the fluid conduit when interrogated by an optical stimulus signal.
Scattering spectroscopy nanosensor	10.06.2015; EP2880423	Hewlett Packard Development Co.	Gibson Gary	A scattering spectroscopy nanosensor includes a nanoscale-patterned sensing substrate to produce an optical scattering response signal indicative of a presence of an analyte when interrogated by an optical stimulus. The scattering spectroscopy nanosensor further includes a protective covering to cover and protect the nanoscale-patterned sensing substrate. The protective covering is to be selectably removed by exposure to an optical beam incident on the protective covering. The protective covering is to prevent the analyte from interacting with the nanoscale-patterned sensing substrate prior to being removed.
Sensor for detecting explosive, and preparation method thereof	28.05.2015; US20150147818	Postech Academy-Industry Foundation	Sungjee Kim	The present invention relates to a sensor capable of detecting an aromatic nitro compound explosive, and a preparation method thereof, and more specifically, to a nanosensor system, and a detection method using the same, wherein a quantum dot-based sensor for detecting an aromatic nitro compound explosive can conveniently detect an aromatic nitro compound explosive with high sensitivity on the basis of a change in energy transfer between quantum dots. The method for detecting an explosive of the present invention makes an explosive come in contact with a quantum dot thin film to which an explosive can combine, and measures a change in fluorescence wavelength, thereby sensing an explosive. According to the present invention, the method for detecting an explosive on the basis of quantum dots uses a change in fluorescence wavelength which is unlike a known detection method using the change in

				quantum dot fluorescence intensity, and thus is not sensitive to a change in surroundings, can carry out rapid detection, and can detect even a low concentration of explosives with high sensitivity. Therefore, the present invention is expected to be extensively commercialized.
Systems and methods for automated reusable parallel biological reactions	28.05.2015; US20150148264	Genapsys Inc.	Hesaam Esfandyarpour	A method comprises magnetically holding a bead carrying biological material (e.g., nucleic acid, which may be in the form of DNA fragments or amplified DNA) in a specific location of a substrate, and applying an electric field local to the bead to isolate the biological material or products or byproducts of reactions of the biological material. For example, the bead is isolated from other beads having associated biological material. The electric field in various embodiments concentrates reagents for an amplification or sequencing reaction, and/or concentrates and isolates detectable reaction by-products. For example, by isolating nucleic acids around individual beads, the electric field can allow for clonal amplification, as an alternative to emulsion PCR. In other embodiments, the electric field isolates a nanosensor proximate to the bead, to facilitate detection of at least one of local pH change, local conductivity change, local charge concentration change and local heat. The beads may be trapped in the form of an array of localized magnetic field regions.

Ultra-sensitive detection of extremely low level biological analytes using electrochemical signal amplification and biosensor	21.05.2015; US20150141272	Neil Gordon	Neil Gordon	This invention allows ultra-low levels of virtually any biological analyte to be detected and quantified rapidly, simply and inexpensively with an electrochemical biosensor using a novel electrochemical signal amplification technique. The invention amplifies detection signals from low level analytes using an innovative sandwich ELISA structure that replaces optical labels with a massive amount of electrochemically detectable guanine rich oligonucleotide tags. Selective binding is achieved with matched pairs of either commercial or custom analyte binding materials such as monoclonal antibodies or single stand DNA. The guanine tags are eluted from the sandwich structures and hybridize with complementary cytosine rich oligonucleotide recognition probes attached to the surface of a biosensor working electrode. An electrochemical technique generates a signal in proportion to the guanine level on the working electrode which is also proportional to the analyte level in the sample. Magnetic separation and a nanosensor are used to improve the signal-to-noise ratio for measuring analyte levels 1,000,000 times lower than enzyme-linked immunosorbent assay (ELISA).
Near infrared fluorescent single walled carbon nanotubes as tissue localizable biosensors	14.05.2015; US20150133752	Massachusetts Institute of Technology	Nicole M. Iverson	A nanosensor for detecting an analyte can include a substrate, a photoluminescent nanostructure, and a polymer interacting with the photoluminescent nanostructure. The nanosensor can be used in in vivo for biomedical applications.
Highly sensitive detection of biomarkers for diagnostics	21.04.2015; US09013690	The Trustees of Princeton University	Stephen Y. Chou	This disclosure provides, among other things, a nanosensor comprising a substrate and one or a plurality of pillars extending from a surface of the substrate, where the pillars comprise a metallic dot structure, a metal disc, and a metallic back plane. The nanosensor comprises a molecular adhesion layer that covers at least a part of the metallic dot structure, the metal disc, and/or the metallic back plane and a capture agent bound to the molecular adhesion layer. The nanosensor amplifies a light signal from an analyte, when the analyte is specifically bound to the capture agent.

Exhibit 1 lists some of the patents related to nanosensors.

Picture Credit: Frost & Sullivan

The patents are focussed on nanosensor technology for chemical, biological or explosives detection. For example Patent EP2885627, assigned to Hewlett-Packard Development Co., pertains to an implantable nanosensor that includes a stent implanted in a fluid conduit and a nanoscale-patterned sensing substrate to detect the analyte in a fluid carried by the fluid conduit.

5. TECHVISION 2015

The TechVision program is the premier offering of Technical Insights, the global technology innovation-, disruption-, and convergence-focused practice of Frost & Sullivan. TechVision embodies a very selective collection of emerging and disruptive technologies that will shape our world in the near future. This body of work is a culmination of thousands of hours of focused effort put in by over 60 global technology analysts based in six continents.

A unique feature of the TechVision program is an annual selection of 50 technologies that are driving visionary innovation and stimulating global growth. The selected technologies are spread across nine Technology Clusters that represent the bulk of R&D and innovation activity today. Each Cluster represents a unique group of game-changing and disruptive technologies that attract huge investments, demonstrate cutting-edge developments, and drive the creation of new products and services through convergence.

Our technology analysts regularly collect deep-dive intelligence on several emerging and disruptive technologies and innovations from around the globe. Interviews are conducted every day with innovators, technology developers, funders, and others who are a part of various technology ecosystems. The respondents are spread across public and private sectors, universities, research institutions, and government R&D agencies. Each technology is rated and compared across several parameters, such as global R&D footprint, year of impact, global IP patenting activity, private and public funding, current and emerging applications, potential adoption rate, market potential, and so on. This organic and continuous research effort spread across several technologies, regions, organizations, applications, and industries is used to generate an annual list of Top 50 technologies that have the maximum potential to spawn innovative products, services, and business models.

Furthermore, we analyse several possible convergence scenarios where two or more of the Top 50 technologies can potentially come together to disrupt, collapse, and transform the status quo. Driven by IP interactivity emanating from each of the top technologies, a whole range of innovative business models, products, and services will be launched at unprecedented speed in the future. We have come up with over 25 such unique convergence scenarios.

The Top 50 technologies we have selected for TechVision 2015 have the power to drive unique convergence and catalyse wide-scale industry disruptions. Frost and Sullivan's TechVision program empowers you with ideas and strategies to leverage the innovations and disruptive technologies that can drive the transformational growth of your organization.

Rajiv Kumar

Senior Partner

For more information contact:

techvision@frost.com

Visit us at:

www.frost.com/techvision

Follow us on:

@TechVision_FS

www.frost.com/techvisionlinkedin

Back to TOC

To find out more about TechVision, access http://www.frost.com/techvision Follow us on @TechVision_FS, http://www.frost.com/techvisionlinkedin

To comment on these articles, write to us at tiresearch@frost.com

You can call us at: **North America**: +1-843.795.8059, **London**: +44 207 343 8352, **Chennai**: +91-44-42005820, **Singapore**: +65.6890.0275

