TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

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1. IMPROVED DIAGNOSIS OF PROSTATE CANCER

The prostate is a gland existing only in males. The function of the prostate is to make some of the fluid that protects and nourishes the sperm cells in semen, rendering the semen more liquid. Nearly all prostate cancers develop from the gland cells that make the prostate fluid which is added to the semen. Two common techniques for prostate cancer detection and screening are direct rectal examination (DRE) and the prostate-specific antigen (PSA) antigen test. The PSA test is considered more effective than the DRE. PSA is a glycoprotein in the blood produced only by prostate cells. PSA reflects the volume of benign and malignant prostate tissue; and prostate cancer is more likely to exist, the higher the level of PSA.

Researchers at the University of Birmingham in the UK have developed a smart sensor chip that can detect subtle differences in glycoprotein molecules and has the potential to enhance the accuracy and efficiency of prostate cancer diagnosis at an early stage. Glycoprotein molecules are proteins that are covalently bound to one or more carbohydrate chains, and provide a range of functions in cell surfaces, structural tissues, and blood. Glycoprotein molecules represent effective clinical biomarkers for detection of prostate cancer or other diseases. The researchers devised a sensor chip containing sensitive receptors along a two-dimensional surface to pinpoint specific, targeted glycoprotein molecules distinguished by their modified carbohydrate chains.

On the other hand, methods that rely strongly on antibodies for prostate cancer diagnosis have deficiencies. The antibody technique can be subject to false positives; and antibodies are expensive to produce and are vulnerable to degradation due to exposure to environmental conditions, such as high temperature or ultraviolet light.

Prior research on detection of glycoproteins focused on the protein of the molecule. However, the protein aspect of glycoproteins may not change even if the body experiences disease.

"Selective glycoprotein detection through covalent templating and allosteric *click*-imprinting," published online in June 17, 2015 in *Chemical Science*, revealed that the smart sensor technology, which exploits reversible covalent interactions with boronic acids and click-chemistry for fabrication of glycoprotein selective surfaces, and focuses on the carbohydrate part of the molecule can reduce the rate of false readings from antibody-based diagnosis. This document noted that the recognition of specific glycoproteins is a key challenge. Furthermore, the self-assembled and imprinted surfaces, containing specific glycoprotein molecular recognition nanocavities, provide high binding affinities, nanomolar sensitivity, exceptional glycoprotein specificity with selectivity as high as 30 fold for prostate specific antigen (PSA) over other glycoproteins.

There can be subtle differences in the complex sugar structure in glycoprotein in samples taken from healthy versus diseased patients. To be able to identify the presence of disease by detecting a certain glycoprotein that has specific sugars in a specific location in the molecule, the team engineered a sensor chip containing a smart surface with nano-cavities that fit the particular target glycoprotein.

In order to create the nano-cavities, the sugar part of the prostate cancer glycoprotein is reacted with a custom-designed molecule containing a boron group at one end (the boron linkage forms a reversible bond to the sugar). The other end of the custom molecule is configured to react with molecules that have been tethered to a gold surface. The glycoprotein is then bound to the surface via its sugar groups, prior to blocking the rest of the surface with a third molecule.

A perfect cast remains after the glycoprotein is removed, via breaking the reversible boron bonds. A special area within the cast with boron-containing molecules can recognize a specific set of sugars. Only the specific target prostate cancer glycoprotein will be able to bind to the highly specific arrangement of boron groups.

The team has focused on making the technology widely accessible. Moreover, the researchers envision that additional investment and collaboration with commercial entities could facilitate adapting the technology to address other diseases.

Details: Dr. Paula Mendes, Professor, Advanced Materials and Nanotechnology, School of Chemical Engineering, University of Birmingham, Edgbaston, Birmingham B15 2TT UK. Phone: +44-0-121-414-5343. E-mail: p.m.mendes@bham.ac.uk

2. STUDY OF INDIVIDUAL NANOPARTICLES COULD IMPROVE HYDROGEN SENSORS

Hydrogen sensors are needed to enable the hydrogen infrastructure to further develop and proliferate. It is increasingly vital to monitor hydrogen in diverse applications, such as industrial process control, combustion control, utility power transformers, and medical applications where the presence of hydrogen is indicative of particular types of health conditions. Moreover, as hydrogen fuel cell engines emerge and become more widely adopted, to provide a zero emissions powertrain for vehicles, hydrogen sensors will be needed to optimize the performance of the hydrogen fuel cell system and help enhance safety.

Large quantities of hydrogen are presently used in industries. For example, oil refineries are large producers and consumers of hydrogen gas for such applications as hydrocracking (the reduction of heavy gas and gas oils to lower molecular weight components), treatment of gas streams, and catalytic reforming (where hydrogen is used to prevent carbon from reacting with the catalyst to maintain production of lighter hydrocarbons and extend the life of the catalyst).

It can be difficult to contain hydrogen and to detect hydrogen leaks. Hydrogen is odorless, colorless, lighter than air, and diffuses quickly. Various types of sensors can be used to detect hydrogen, such as ultrasonic gas leak detectors, electrochemical sensors, catalytic bead sensors, metal oxide semiconductor sensors, thermal conductivity sensors, optical sensors, and solid-state resistive hydrogen sensors.

Owing to rapid dispersion, wind direction, and direction of leaks, electronic hydrogen detectors can have difficulty detecting leaks as little as a few inches away from the leak source. Furthermore, the electronic sensor may not indicate the source of the leak.

Researchers at Chalmers University of Technology in Sweden have developed an innovative means of studying individual nanoparticles using plasmonic nanospectroscopy and found that individual particles can have quite different properties, although they may seem identical. The discovery could facilitate development of innovative materials or newer applications, such as hydrogen sensors for fuel cell vehicles.

The researchers revealed that a deeper understanding of the physics of the interaction of nanomaterials with molecules in their environment is obtained by investigating the individual nanoparticles as opposed to investigating many nanoparticles simultaneously.

In applying plasmonic nanospectroscopy to study hydrogen absorption into single palladium nanoparticles, the researchers discovered that particles with exactly the same shape and size may exhibit differences as great as 40 millibars in the pressure at which hydrogen is absorbed. Such insights could become beneficial in, for example, development of sensors that are able to detect hydrogen leaks in fuel vehicles.

It can be challenging to design materials for hydrogen sensors that have a very linear and reversible response to hydrogen. It can be helpful to understand the reasons for the differences among ostensibly identical individual particles and how this situation can make the response irreversible in a particular range of hydrogen concentration.

The Chalmers team used low intensity, visible light, which provides a non-invasive, non-disruptive means to investigate the individual nanoparticles. The approach is compatible with ambient conditions and can allow for studying specific nanoparticles in environments that closely match realistic settings.

Christoph Langhammer, associate professor, applied physics, Chalmers University of Technology, and leader of the project, hopes that the research will create an experimental paradigm in which the investigation of individual nanoparticles will become standard practice and envisions that their approach will be applied to more complex processes and materials and could be used to measure even smaller nanoparticles in the future.

Details: Dr. Charles Langahhammer, Associate Professor, Applied Physics, Chalmers University of Technology, SE-41296 Gottenburg, Sweden. Phone: +46-31-772-3331. E-mail: clangham@chalmers.se. URL: http://www.chalmers.se

3. OPTOFLUIDIC TECHNIQUE ENHANCES FLU DETECTION

Rapid diagnosis of influenza is beneficial for the health of an individual and for the community. Diagnosis of influenza can be difficult due to the variability of symptoms and various other causes of influenza-like illnesses.

Furthermore, there are limitations to conventional test techniques for influenza. Point-of-care test kits, which generally involve immunochromatographic assays using monoclonal antibodies directed against influenza A and B nucleoprotein are expensive and have a limited shelf life of one to two years. Inaccurate results can occur due to poor specimen collection and misinterpretation of test strips.

Immunofluorescence assays, based on the same principle as the point-of-care test, detect interaction between a viral antigen and specific antibodies, and are performed in a laboratory. Such assays are more labor intensive than point-of-care tests (which may delay the results) and require a specialized laboratory, fluorescent microscope, and technical expertise.

Nucleic acid tests, which involve molecular assays for detecting the influenza virus nucleic acid, have been the most sensitive and specific diagnostic tests for influenza. Nucleic acid tests are less labor intensive than immunofluorescence assay, but can be subject to delayed results (of 24-48 hours) and are more costly due to the need for technical expertise and specialized equipment.

Optofluidics embodies the fusion of optics and microfluidics and involves the use of light to control the flow of fluids. Optofluidics is used in lab-on-chip devices, which are miniature systems for analyzing and sorting particles or cells. Optofluidic chips and lab-on-chip devices can enable enhanced point-of-care analysis of minute, low-concentration biological samples. Such solutions can streamline costs by consuming low volumes of fluid and are capable of analyzing samples in extremely tiny quantities, and can enable improved process control and high throughput analysis.

Researchers the University of California, Santa Cruz, and Brigham Young University, USA, have developed optofluidic chip-based sensing technologies to enhance rapid detection and identification of multiple biomarkers, enabling diagnostic assays for multiple strains of flu virus on a tiny chip. The standard flu test can check for around 10 different strains of flu. The researchers devised a new means, using the optofluidic chip, to assay around 10 to 15 strains of flu.

The optofluidic chip was fabricated by collaborators at Brigham Young University under the direction of Aaron Hawkins, professor, department of electrical and computer engineering.

During the past decade, Holger Schmidt, professor of electrical engineering at UC Santa Cruz's Jack Baskin School of Engineering, and collaborators at Brigham Young University developed chip technology to optically detect single molecules. Such optofluidic chips could enable portable diagnostic instruments that offer low-cost, rapid identification of specific disease-related molecules or virus particles.

In the latest work, Schmidt innovatively applied wavelength division multiplexing to the optofluidic device. Wavelength-dependent spot patterns were created in an intersecting fluidic channel by superimposing multiple wavelengths of light in an optical waveguide on the chip. Depending on the wavelength of light that the markers absorb, the virus particles labeled with fluorescent markers provide distinct signals as they travel through the fluidic channel. For example, each color of light generates a different spot pattern in the channel. Therefore, if the virus particle is labeled to respond to blue light, it will illuminate nine times as it passes through the channel. If it is labeled to respond to red light, it will light up seven times.

The technique was tested using three different influenza subtypes labeled with different fluorescent markers. In the initial test, each strain of the virus was labeled with a single dye color, and three wavelengths of light were used to detect the strains in a mixed sample. In the second test, one influenza strain was labeled with a combination of the colors used to label the other two strains. The detector again was able to distinguish among the viruses based on the distinctive signals from each combination of markers. The combinatorial approach is beneficial, since it increases the number of different targets that can be detected with a given number of wavelengths of light.

In the testing, each viral subtype was separately labeled with a fluorescent dye. In a real-world diagnostic assay, fluorescently labeled antibodies could be used to selectively attach distinctive fluorescent markers to different strains of the flu virus.

Prior studies revealed the sensitivity of Schmidt's optofluidic chips for detection of single molecules or particles. The demonstration of multiplexing in the recent work can further on-chip bioanalysis. Compact instruments based on the chip could provide versatile diagnostic assays that could target a range of biological particles and molecular markers.

Moreover, Schmidt’s team has reported development of a hybrid device that integrates a virus-detecting optofluidic chip and a microfluidic chip used for sample preparation.

Details: Dr. Holger Schmidt, Professor, Electrical Engineering, Jack Baskin School of Engineering, University of California, Santa Cruz, 1156 High Street, Santa Cruz, CA 95064. Phone: 1-831-459-1482. E-mail: hschmidt@soe.ucsc.edu. URL: https://www.soe.ucsc.edu

4. ENHANCED DETECTION OF GASTRIC ACTIVITY

Currently, external sensors on the surface of the stomach are typically used to detect electrical signals that are indicative of muscular activity within the stomach. Such devices record the electrical signals that travel through the stomach muscles and control the muscles' contractions. They are also used to record electrical signals from the intestines.

However, external sensors placed on the surface of the stomach may not be able to accurately detect the stomach's signals, and recording of the signals can be disrupted, depending on the patient's movements. An implantable, wireless solution can provide more detailed, accurate, and reliable information about gastric activity in the stomach.

Indicative of key opportunities for wireless, implantable devices for gastric electrical impulse measurement, Aydin Farajidavar, assistant professor, School of Engineering and Computing Sciences, New York Institute of Technology (NYIT) has garnered a $457,000 grant from the National Institutes of Health (NIH) to develop WINGS (Wireless Implantable NeuroGastroenterology System) technology, an implantable wireless system to investigate the body's gastric and digestive systems.

The grant is part of an NIH initiative dedicated to investigate peripheral nerves, which are outside of the brain and spinal cord. The SPARC (Stimulating Peripheral Activity to Relieve Conditions) program funds projects that reveal information about how peripheral nerves control the organs in the body.

Farajidavar's research is focused on devising a safe method to monitor the electrical impulses that generate rhythmic movements and contractions in the stomach, which are vital for gastric health and adequate digestion. Dysrhythmias, or problems with gastric movements, can result in disorders that prevent the stomach from digesting food properly. Abnormal digestion of food can create issues with respect to blood sugar levels, nutrition absorption, as well as painful cramps.

Farajidavar's highly compact wireless implantable device is designed to be implanted in the patient during an endoscopy, a non-surgical procedure used to examine an individual's digestive tract (for example, esophagus, stomach, duodenum) using a thin, flexible tube with a light and camera attached to it. The device would be inserted by opening a tiny flap inside the stomach. The implanted device would then transmit data regarding the stomach's slow waves to a small patch worn on the skin. The data would be transferred via the patch to a unit that enabled physicians to monitor and map the electrical activity in the stomach. The system would be wirelessly recharged through a patch, with the potential to remain in the body for a month or longer.

The ability to monitor gastric conditions in long-term investigations and to gain deeper knowledge about gastric waves and signals, can allow for development of specific therapies for individuals experiencing gastric disorders.

The device will be initially tested in animals. Farajidavar's research team, which includes scientists from Auckland Bioengineering Institute (New Zealand), Pennsylvania State University, and North Shore-Long Island Jewish Health System, hopes for having clinical trials for the technology in a few years.

Details: Dr. Aydin Farajidavar, Director of the IMS Lab and Assistant Professor, School of Engineering and Computing Sciences, New York Institute of Technology, P.O. 8000 Northern Blvd., Harry Schure Hall, Room 226B, Old Westbury, NY 11568. Phone: +516-686-4014. E-mail: afarajid@nyit.edu. URL: http://www.nyit.edu.

5. RECENT PATENTS IN THE FIELD OF OPTOELECTRONIC SENSORS

An optoelectronic sensor is a device that is capable of converting optical signals into electrical signals or vice versa. An optoelectronic sensor responds to optical power, emits or modifies optical radiation, and utilizes optical radiation for internal operations. Such sensors can detect, for example, visible, infrared or ultraviolet light. Optoelectronics sensors also help to increase the efficiency of electronic devices.

There are a number of optoelectronics sensing technologies such as photodiodes, photoelectric sensors, infrared sensors, image sensors, fiber optic sensors. Advancements in CMOS (complementary metal oxide semiconductor) image sensors have boosted opportunities for of low-cost optoelectronic sensors in applications such as consumer electronics and automotive. Optoelectronic sensors that typically use a photodiode to generate an electrical signal proportional to the amount of incident light on its area are used in, for example, medical equipment. Light sensors containing photodiodes are used in gesture, color, and proximity detection.

University laboratories, academic and research institutions, governments and private companies are coming together to form innovation-led clusters for optoelectronics to develop optoelectronics sensors with more sensitivity and the capability to detect more than one object. Florida Photonics (USA), Optonet (Germany), and the Association for Photonics Industry (Japan) are some of the innovation-led clusters formed with a key focus on optolectronics. There is

strong potential for advanced optoelectronic sensors, particularly image sensors, in the mobile devices market. As a result, companies with technologies targeted at such markets are finding opportunities for increased funding.

Patent filing trends under optoelectronics sensors can also be analyzed with respect to the focus area or applications, such as consumer electronics, automotives, and security and surveillance. At present, consumer electronics and the automotive sector are major focus areas and a large number of patents have been filed in those segments. Security and biodefense are emerging fields. Key growth opportunities lie in infrared imaging in which uncooled infrared sensors have reached price points and form factors suitable for mobile devices. This is an emerging segment with the potential to attract major interest from end users. Quantum film optoelectronics image sensors are one of the focus areas, which use quantum dots for better light capturing. Post capture focusing and mobile infrared imaging are some of the additional focus areas in optoelectronics sensing.

Observation of the patent filing scenario reveals that optoelectronics sensors are finding opportunities in the automotive industry. Image sensors are finding increasing applications by providing safety and convenience solutions in automobiles. Image sensors have been used in safety applications, such as lane departure warning, park assist, blind spot detection, and biometric drowsy-driver warning systems. As these features become mandatory in the US and the European Union, optoelectronics will witness major growth.

In North America, which is a major developer of optoelectronics, a key area of focus has been on the development of infrared imaging technology. In Europe, there is emphasis on the development of optoelectronics using printing technologies. The adoption is fairly high in this region in industrial applications such as machine vision. Optoelectronic sensors tend to employ relatively mature sensing technologies, which can mitigate their disruption potential.

A recent patent in optoelectronic sensors (US20150268067), assigned to Datalogic IP Tech S.R.L., pertains to an optoelectronic sensor comprised of a multi turn encoder that is actuated by a knob to measure the rotation speed of the object and detect the rotation mode.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Optoelectronic sensor for detecting one or more features of an object	24.09.2015; US20150268067	DATALOGIC IP TECH S.R.L.	Alberto Fabbri	An optoelectronic sensor for detecting one or more features of an object comprises means for controlling the operation of said sensor and a face (**20**) for interaction with an operator provided with adjusting means (**22, 23**) for adjusting operating parameters of the sensor. The means for controlling is connected to the adjusting means (**22, 23**) to detect a setting of the operating parameters and the adjusting means (**22, 23**) comprises a knob (**22**) which is rotatable around an axis (A) for adjusting at least one predetermined parameter among said operating parameters. The sensor comprises a multiturn encoder (**28**) that is actuatable by the knob (**22**) and the means for controlling are connected to the multiturn encoder (**28**) to obtain a rotation mode of said knob, for example a rotation direction and further/or a rotation speed, so as to associate with said detected rotation mode a corresponding setting mode of the predetermined parameter, for example a setting with a first coarse sensitivity, or a second fine sensitivity.
Optoelectronic sensor and method for detecting objects in a monitored zone	06.08.2015; US20150219763	Sick AG	Ulrich Nubling	An optoelectronic sensor (**10**) is provided for detecting objects in a monitored zone (**18**), in particular a laser scanner, which has a light transmitter (**20**) for transmitting a transmitted light beam (**24**), a base unit (**14**) and a sampling unit (**12**) rotatable with respect to the base unit (**18**) for the periodic sampling of the monitored zone (**12**) by the transmitted light beam (**14**) and having a first circuit board (**34**), a light receiver (**32**) for generating a received signal from the light (**28**) remitted by objects in the monitored zone (**18**) and an evaluation unit (**34, 42, 50, 52**) for detecting information on objects in the monitored zone (**18**) with reference to the received signal. In this respect, the base unit (**14**) has a bearing (**40**) in which the first circuit board (**34**) is rotatably supported at its outer periphery with respect to the base unit (**14**).
Optoelectronic sensor device, in particular laser scanner, having an adapted receiving unit for optimized reduction of the reception level	25.06.2015; US20150177368	Valeo Schalter und Sensoren GmbH.	Heiner Bayha	The invention relates to an optoelectronic sensor device (**1**) for a motor vehicle, for detecting objects located in the surroundings of the motor vehicle, having a transmitting unit (**2**) for emitting an optical transmission signal (**5**), having a receiving unit (**7**) for receiving a reception signal (**8**) which is the transmission signal (**5**) reflected by an object, wherein the receiving unit (**7**) has at least two receiving elements (**9, 10, 11**) which are arranged distributed along a distribution direction (**12**), and reception optics (**13**), in particular a receiving lens which is positioned ahead of the receiving elements (**9, 10, 11**) in the propagation direction (**14**) of the reception signal (**8**), having a securing device (**22**) for securing the receiving optics (**13**), and having a diaphragm (**21, 21'**) for reducing the intensity of the reception signal (**8**), wherein the diaphragm (**21, 21'**) is secured to the securing device (**22**).
Optical module and method for producing an optoelectronic sensor	16.04.2015; US20150103425	Sick AG	Johannes Eble	An optical module (**10**) having at least one beam-forming element (**14**) and having at least two retainer brackets (**20**) for fastening the optical module (**10**) to a carrier (**30**) are provided. In this connection the retainer brackets (**20**) have a first support element (**22***a*) at a first spacing with respect to the lens (**14**) and a second support element (**22***b*) at a second spacing different from the first spacing with respect to the beam-forming element (**14**) in order to selectively fasten the optical module (**10**) to the carrier (**30**) at the first spacing or at the second spacing.

Title	Publication Date/Publication Number	Assignee	Inventor	Abstract
Method for operating an optoelectronic proximity sensor	29.01.2015; WO/2015/011094	Osram Opto Semiconductors GmbH	Halbritter, Hubert	The invention relates to a method for operating an optoelectronic proximity sensor (1), wherein the proximity sensor (1) comprises a radiation-emitting component (2), a radiation-detecting component (3) and a control unit (4), the radiation-emitting component (2) is operated by means of a pulsed current (Ie), during a measurement period (Tm) the pulsed current (Ie) of the radiation-emitting component (2) has in each case an on-time (ton) and an off-time (toff), wherein the pulsed current (Ie) has a pulse current intensity (Ion) during the on-time (ton), and the control unit (4) evaluates a detector signal (Id) of the radiation-detecting component (3) and lowers the pulse current intensity (Ion) for a subsequent measurement period (Tm), when the detector signal (Id) exceeds a threshold value (Ith) during at least one measurement period (Tm).
Three-dimensional optoelectronic simulation method for enhancing accuracy of crosstalk prediction for image sensor	29.10.2014; KR1020140125622	Samsung Electronics Co., Ltd.	Lee, Wook	A three-dimensional optoelectronic simulation method for an image sensor comprises the following steps of: generating a process simulation result including a doping profile of a silicon substrate in the image sensor; generating a simulation result of a structure after the back end of line of the image sensor; generating an expanded result by selectively reusing a result of combining the process simulation result with the structure simulation result after the back end of line, and generating a result of dividing the expanded result by pixel; generating an optical crosstalk simulation result of the image sensor by receiving the structure simulation result after the back end of line and an optical mesh; and generating a finial simulation result including an electrical crosstalk simulation result of the image sensor by receiving the divided result by pixel and the optical crosstalk simulation result. COPYRIGHT KIPO 2015
Optoelectronic inclination sensor	15.05.2014; WO/2014/072205	Sartorius Lab Instruments GmbH & CO. KG	Müller, Ralf	The invention relates to an inclination sensor (1) with a housing which is filled with a liquid (5) and a gas bubble (6), and is closed off by a convex-curved cover layer (4), along which the gas bubble (6) moves when the inclination sensor (1) is tilted relative to a horizontal reference plane. The inclination sensor (1) comprises a light source (7) and at least one photodetector (8) that is arranged opposite the cover layer. The liquid (5) has an absorption coefficient greater than 0.05 mm-1 for the wavelength of the light source (7).

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

Picture Credit: Frost & Sullivan

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