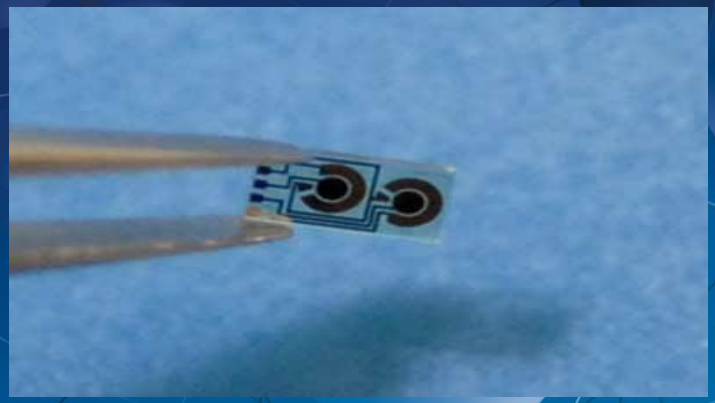
Sensor Technology (TechVision)



Biosensors for Metal Contamination Detection and Healthcare Applications

Sensors poised to impact biomedical and other applications

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FROST & SULLIVAN

Contents

Technology Innovations in Biosensors

DNA-based Handheld Gold Biosensor

University of Nebraska–Lincoln, Lincoln, Nebraska

Inexpensive, Portable, Reusable Sensor to Detect Au (III) Gold Ions

Rebecca Lai's team at the University of Nebraska-Lincoln is developing a sensor to detect gold that is based on the interactions of gold ions with adenine. The sensor measures electric current passing from an electrode to a methylene blue tracer module. Upon binding to the AU (III) gold ion, the flexibility of the oligoadenine (short adenine chain) DNA probe is hindered, reducing current from the tracer module. The change in current is used to assess the Au (III)'s concentration.

Competing Aspects

- The gold sensor (and those for other metals) is fabricated on litmus-sized paper strips and designed to be inexpensive, portable, reusable.
- Over time, the technology has the potential for online, real-time monitoring of gold or (using a DNA building block for which the target metal has an affinity) other metal contaminants, such as lead, mercury, arsenic, and so on. No time-consuming tests would be required.

Technology Readiness Level:3

A patent was applied for in 2014.

Attributes of Innovation

The researchers have reported how oligoadenines (short adenine chains) are able to be used to create DNA electrochemical biosensors capable of measuring the presence and concentrations of a target metal in water. The gold sensor can be reused by subsequently removing the Au (III) from the sensor by applying another ligand.

Market Readiness & Commercialization Strategy

The DNA-based biosensors need further refinement before they are ready for commercial availability.

Impact & Opportunities

Commercialization/Widescale Adoption Year

Licensing partners are being sought. The technology has opportunities over the long-term.

Impact on Industries/Specific Applications

Water monitoring; geophysical exploration (mining). There is a need for new, improved detection of gold, which has opportunities for higher demand for pharmaceuticals or scientific requirements.

Market Potential/Opportunity

The gold, and other metal-detecting, sensors can have key opportunities in water contaminant detection.

Technology Convergence

The technology could address needs for more convenient, inexpensive and reliable sensors to detect metal contaminants or to detect metals (such as gold), which have high demand.

Label-Free Biosensor

Moscow Institute of Physics and Technology– Graphene-based biosensor

Tech. Profile

The researchers have developed a graphene-based biosensor and enabled it with the help of surface plasmon resonance (SPR). The biosensor is comprised of a thin gold film, glass substrate and graphene oxide linking layer. The sensors are employed to detect a low concentration of a biologically significant molecular substance such as bacteria, viruses, DNA, proteins and many more.

Growth Potential

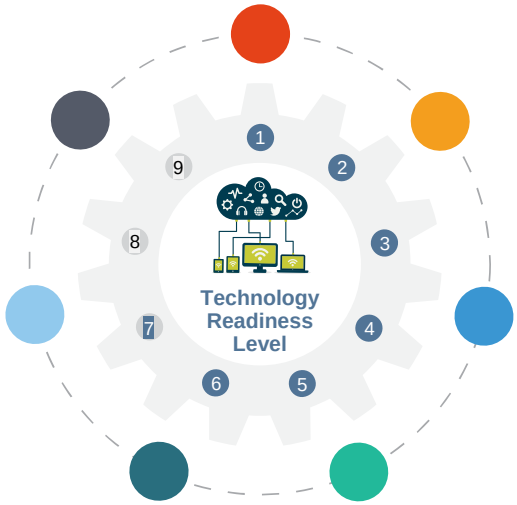
According to outside sources, the total annual biosensor chip market is around $300 million. The advantage and excellent properties of biosensors based on graphene will help to compete for market share.

Market Opportunity

- Pharmaceutical and scientific research
- Medical diagnostics
- Food quality control
- Detection of toxins

Competing Aspects

Radioactive and fluorescent labels are not needed to develop the biosensor. This further helps to lower the cost and provide accurate detection.



Technology Convergence

Future biosensors will blend molecular biology with computational software at the atomic scale to create smart biosensors.

Innovation Attributes

The kinetics of the active substances on different targets can be observed in real time. The data collected can help to gain information about drug toxicity and its efficacy.

Market Entry Strategies

For medical applications, collaboration with the experts in the medical field is expected to the be the best way to enter the market. The regulatory barrier is a huge challenge for start-up companies in the field.

Biosensor that Works in Three Ways Simultaneously

University of Pennsylvania–Graphene-based biosensor

Tech. Profile

The researchers have developed a graphene-based biosensor comprised of a silicon nitride substrate. The substrate is coated with graphene and a thick layer of single carbon atoms. The sensor is capable of working in three different modes—optical, electrical and mechanical. Since the sensor is comprised of graphene that possesses unique electrical properties all the three modes are allowed to operate simultaneously without any interference.

Year of Impact

The sensor is expected to be commercialized within circa the next five years. In addition, the technology can have keen potential for biomedical applications.

Market Opportunity

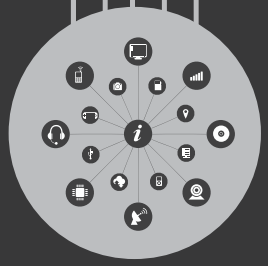
The sensor can be used to diagnose certain cancers, where the patients have different blood biomarker concentrations. The sensor can be used to detect a wide range of proteins.

Competing Aspects

It detects all types of proteins in blood biomarkers. In addition, it differentiates the charge and mass of different proteins

Innovation Attributes

When the sensor is operating under the electrical mode, the change in the number of carriers is taken into consideration. Under the mechanical mode, total mass is taken into consideration and in the optical mode, reflection is measured.



Market Entry Strategies

The project was funded under the grant IIP-1312202 and ECCS-1408139 by the National Science Foundation. The technology is expected to be commercialized with the help of a licensing strategy.

Progress

The researchers are currently working on investigating the feasibility of multimodal sensors to identify proteins from unknown samples.

Technology Readiness Level: 1 2 3 4 5 6 **7** 8 9

Wearable Biosensor

Vital Connect–HealthPatch wearable biosensor

vitalconnect

Tech Profile

The HealthPatch wearable biosensor is a patch that resembles a disposable band-aid, weighing only 10 grams. A thickness of 6 mm makes it a highly light, comfortable and a discrete product that is placed on the chest for continuous monitoring of a number of health vitals. The HealthPatch also comprises ECG (electrocardiograph) electrodes to detect heart rate variability, a 3-axis MEMS accelerometer to detect motion, and a thermistor to detect skin temperature.

Competing Aspects

The HealthPatch wearable biosensor consists of a disposable zinc air battery that has an average battery life of 72 hours and is fully recyclable, putting less pressure on non-biodegradable medical waste.

Innovation Attributes

The HealthPatch biosensor is capable of tracking a broad range of vital sign measurements that include electrocardiograph (ECG), heart rate, heart rate variability, skin temperature, respiratory rate variability, posture detection, fall detection and counting steps.

Market Entry Strategies

Vital Connect has partnered with LifeWatch AG, a company headquartered in Switzerland that collects patient data and transmits it to patient monitoring centers for a detailed analysis by clinicians. Subsequently, LifeWatch AG prescribes HealthPatch solutions to the treating physicians.

Impact & Opportunities

Wide Scale Adoption

Vital Connect has developed a highly reliable solution capable of capturing clinical grade measurements in a continuous and non-invasive manner that can address the increasing interest in individuals' health and wellness.

Market Opportunity

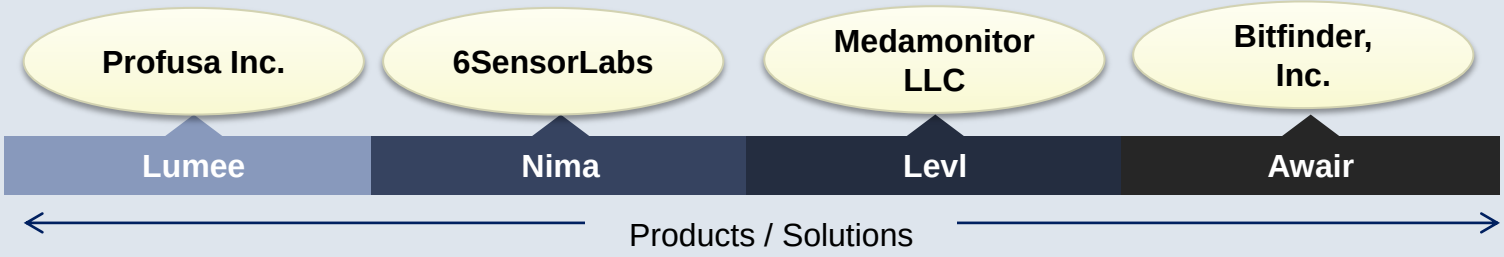
The HealthPatch wearable biosensor, which uses leading-edge sensor and chip technologies, provides clinical grade information that has been specially designed to support users who proactively look to monitor their health or fitness and those with health issues (for example, people who are medically unfit to travel to the hospital on a regular basis for check-ups).

Technology Readiness Level 1 2 3 4 5 6 7 8 9

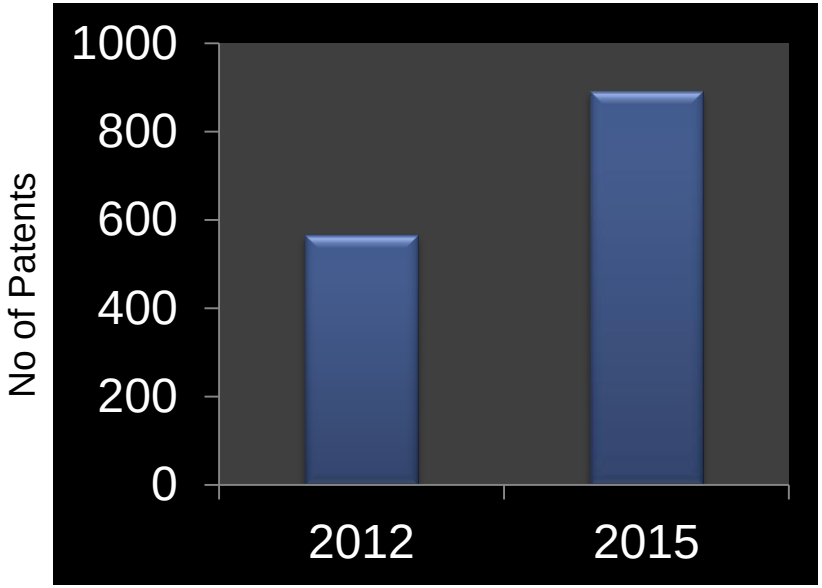
Strategic Insights

Strategic Insights

Companies to Watch in 2016



Intellectual Property (IP)



Source: WIPO/Frost & Sullivan

Interest in biosensors for clinical applications is growing rapidly, and end-users, such as clinicians, have realized the benefits of such devices. Biosensors are finding new applications, for example, in drug discovery and therapeutics, as well as in point of care and home diagnostics. Large-scale initiatives, such as the Human Genome Project, have generated new approaches to protein detection and genetic analysis in disease detection using biosensors. Advancements in medical, biological, and environmental applications are widening the range of applications for biosensors.

Strategic Insights

Drivers

- ✓ Diverse application areas of biosensors boosts adoption and lead to new product development
- ✓ Strong R&D efforts
- ✓ Technology advancements
- ✓ Compact sensor design decreases production cost
- ✓ Increase in disease incidents (such as diabetes) and the aging population

Restraints

- Ẋ Miniaturization in sensors
- Ẋ Detection limit
- Ẋ Device readout time
- Ẋ Need for regulatory compliance
- Ẋ Funding issues
- Ẋ In clinical applications for diagnosis of infectious diseases, challenges have included sample preparation, system integration

Focus Areas

Nanotechnology
Compact design
Point of care devices
Home-based monitoring devices
Wearable biosensors
Drug delivery

Funding

- The majority of start ups tend to depend on bank financing, angel investors and strategic tie-ups for funding.
- The government intends to increase the uptake of these cost-effective devices and promote the use of medical devices based on advanced or breakthrough technologies for easier and quicker results.
- The government initiatives in the UK with the Technology Strategy Board (TSB) have promoted a healthy R&D culture. Organizations such as EPSRC (Engineering and Physical Sciences Research Council), BBSRC (Biotechnology and Biological Sciences Research Council), MRC (Medical Research Council) and NERC (Natural Environment Research Council) have constantly funded academia to be strategically involved with the industry.

The 2020 Scenario

- Sensor manufacturers will try and incorporate multiple features in single products by collaborating with third parties during the development stage to produce micro electrodes for detection.
- Readout times in a number of sensor devices will extend up to 20 seconds. This can be reduced by incorporating high performance microprocessors or microcontrollers to display the results instantly.
- Biosensors are expected to continue to improve and advance with respect to such characteristics as sensitivity, selectivity, miniaturization, response time.

Key Patents and Industry Interactions

Key Patents

No.	Patent No.	Publication Date	Title	Assignee
1	**WO/2016/025646**	18.02.2016	Cell-based biosensor array and associated methods for manufacturing the same	Axion Biosystems Inc.
	A cell-based biosensor array includes a base plate having a plurality of substantially transparent areas. The cell-based biosensor array also includes a flexible substrate coupled to the base plate and having disposed thereon a plurality of electrode sets, a plurality of terminal contacts, and a plurality of conductive traces. Each electrode set is disposed proximate a respective one of the substantially transparent areas, and each electrode set includes at least one electrode configured to detect an electric signal. Each terminal contact is associated with a respective one of the at least one electrode and disposed proximate a perimeter of the flexible substrate. Each conductive trace is electrically coupling a respective at least one electrode to the corresponding terminal contact. A first portion of flexible substrate including the electrode sets is disposed on a first surface of the base plate. A second portion of the flexible substrate including the terminal contacts is disposed on a second surface of the base plate.			
2	**US 20160041117**	11.02.2016	Methods of scaling data used to construct biosensor algorithms as well as devices, apparatuses and systems incorporating the same	Roche Diabetes Care Inc.
	Methods are disclosed for scaling body fluid analysis data to correct and/or compensate for confounding variables such as hematocrit (Hct), temperature, variations in electrode conductivity or combinations thereof before providing an analyte concentration. The scaling methods utilize current response data obtained from an AC block applied prior to a DC block to minimize the impact of such confounding variables upon the observed DC current response before creating descriptors or algorithms. The scaling methods therefore compensate the measured DC current by using data from the AC block made on the same sample. Also disclosed are devices, apparatuses and systems incorporating the various scaling methods.			

Key Patents (continued)

No.	Patent No.	Publication Date	Title	Assignee
3	**US20160033490**	04.02.2016	Linked peptide fluorogenic biosensors	CArnegie Mellon University
	Biosensors, compositions comprising biosensors, methods of producing biosensors, and methods of using biosensors are disclosed. The biosensors comprise a fluorogen-activating peptide and a blocking peptide. The blocking peptide associates with the fluorogen-activating peptide thereby blocking an active domain of the fluorogen-activating peptide. The fluorogen-activating peptide and blocking peptide are covalently linked in certain embodiments through a peptide linker. The peptide linker may contain an amino acid sequence that is specifically recognized as a modification substrate by a cognate enzyme. The fluorogen-activating peptide and the blocking peptide at least partially disassociate when the linker is modified by a cognate enzyme, thereby allowing the fluorogen-activating peptide to bind a cognate fluorogen and modulate a fluorescence signal.			
4	**WO/2016/018148**	04.02.2016	Biosensor comprising a modified metal surface and method for the modification of a metal surface	Biomarque B.V.
	The present invention relates to a device for the detection of an analyte in a fluid, the device comprising: (a) a working electrode comprising a modified metal surface, wherein: (1) the metal is selected from the group consisting of Ru, Rh, Pd, Ag, Ir, Pt and Au; (2) an enzyme is covalently attached to the metal surface via an alkyloxy or an alkenyloxy moiety and, optionally, a linker moiety; (3)the alkyloxy or alkenyloxy moiety is covalently bonded to said metal surface via the alkyloxy or alkenyloxy O- atom; and (4) the linker moiety, if present, is covalently bonded to theenzyme and to the alkyloxy or alkenyloxy moiety; (b) a reference electrode; and (c) means for detecting an electricalsignal, the means being operationally coupled to at least working electrode (a) and reference electrode (b). The device according to the invention is also referred to as a biosensor. The invention also relates to a process for the modification of a metal surface and to a modified metal surface obtainable by the process. Furthermore, the invention relates to an electrode comprising said modified metal surface, and to a biosensor comprising said modified metal surface.			

Industry Interactions

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