FONDAZIONE ISTITUTO ITALIANO DI TECNOLOGIA

A TECHNOLOGY TEASER

THREE-DIMENSIONAL DISPERSIBLE NANORESONATORS

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HEALTH TECHNOLOGIES

Istituto Italiano di Tecnologia – Mission and History

The Foundation is intended to promote Italy's technological development and advanced education, consistent with national policies for scientific and technological development, thus strengthening the national production system.

For this purpose, the Foundation:

- helps and accelerates the development, within the national research system, of scientific and technological skills able to facilitate state of the art technological advancements of the national production system;

- develops innovative methods and know-how, in order to facilitate new high-level practices and positive competitive mechanisms in the field of national research;

- promotes and develops scientific and technological excellence, both directly, through its multi-disciplinary research laboratories, and indirectly, through a wide collaboration with national and international laboratories and research teams;

- carries out advanced training programs as a part of wider multi-disciplinary projects and programs;

- fosters a culture based on sharing and valuing results, to be used in order to improve production and for welfare-related purposes, both internally and in relation to the entire national research system;

- creates technological understanding about components, methods, processes and techniques to be used for the implementation and interconnection of innovative products and services, in strategic areas for the competitiveness of the national production system;

- pools research scientists operating in various research institutes and establishes cooperation agreements with high-level, specialized centers;

- promotes interactions between basic research and applied research facilities, encouraging experimental development;

- spreads transparent, merit-based selection mechanisms for research scientists and projects, in compliance with globally approved and established criteria.

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EXECUTIVE SUMMARY

The object of this IIT technology is to provide 3D nanoresonators which are free, meaning they are not fixed to any substrate and dispersible in a fluid medium. Furthermore, these 3D nanoresonators have resonance properties tunable over a wide spectrum of wavelengths as a result of the design of the resonant structure, while being sensitive to the chemical and physical characteristics of their environment or to the presence of specific molecular species. The nanoresonators produced according to this technology have characteristics which significantly extend their range of applications, by combining the properties of design flexibility of the resonant frequency over a wide electromagnetic spectrum, typical of the prior art 2D nanoresonators, with the dispersibility properties of resonant nanoparticles.

These technologies represent a unique chance for companies active in nanosensor market. IIT assets appear well positioned for an out-licensing strategy, providing the licensee partner with the ability to take care of the late stage development, CE certification, scale-up and production process. The licensee should guarantee a high probability of market success based on consolidated marketing & distribution organization. A typical licensing strategy based on entry fee and subsequent royalties on net sales can be envisaged.

In the following paragraphs an IP outlook and a description of the IIT technology are available. Furthermore, the IIT Business and Financial Analysis Office (BFAO) implemented a market analysis and a competitive analysis highlighting the profiles of the most active industrial players in the sector.

INTELLECTUAL PROPERTY

PCT International Application #	PCT/IB2013/061433 - 31 December 2013
Priority Application #	TO2013 A000001 - 02 January 2013
Regional Patent Applications filed	**US** 14/655620, **EP** 13831876.1
Applicant	Fondazione Istituto Italiano di Tecnologia Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna Scuola Normale Superiore
Inventors	Bifone Angelo, Clericò Vito, Tredicucci Alessandro, Pingue Pasqualantonio, Boni Adriano, Recchia Fabio.
Title	A three-dimensional dispersible nanoresonator structure for biological, medical and environmental applications and a method for manufacture thereof

Short Description

A three-dimensional structure of an electromagnetic nanoresonator, comprising a stack of laterally confined layers that includes at least a first and a second layer of a respective conductive material between which a dielectric layer is interposed, which define a resonant equivalent electrical circuit having a nominal resonant frequency which is a function of the geometrical dimensions of the structure, wherein said layers of conductive material and said dielectric layer have at least a respective accessible surface area, adapted to be exposed in a liquid environment of immersion of said structure.

IIT TECHNOLOGY

The current technology relates to nanosensors, in particular nanosensors for biological, medical and environmental applications and, more specifically, a three-dimensional (3D) nanoresonator structure. Nanoresonators, also known as nanoantennas, are resonator devices of nanometric dimensions which, when exposed to a wide spectrum exciting electromagnetic radiation, show increased absorption at a natural resonant frequency determined by the characteristics of the resonator and/or by the interactions with the environment in which they are immersed; this frequency is located between the THz range and the near infrared wavelengths.

Two classes of nanoresonators, namely structured nanoresonators and nanoparticles with resonant properties, are known in the literature. The most common structured nanoresonators are based on a 2D open-loop configuration; their 2D structure has to be supported on the surface of a substrate which they cannot be separated from. The resonance of these devices can be tuned over a wide range of wavelengths by suitable design of the resonance structure, but their use is limited by the dimensions of the array and by the nature of the substrate which they are anchored to. These types of nanoresonators are typically used for *in vitro* biological analysis but have the disadvantage that they cannot be injected into a living organism and traced *in vivo*, because they cannot be separated from the substrate.

Unlike structured nanoresonators, some free metallic nanoparticles, which can be produced by chemical synthesis, are known to act as nanoresonators because of the resonance of the plasmon waves which are established on the surfaces of the molecules. As a general rule, resonant nanoparticles, not bound to any substrate, can be freely dispersed in a fluid medium and can be used advantageously for *in vivo* applications, by exploiting their capacity to bind to molecular species present in the fluid medium, which affect their resonance properties. Unfortunately, however, such resonance properties are mainly determined by the intrinsic characteristics of the material of the nanoparticles, and since the chemical synthesis process does not enable complexes of nanoparticles to be produced with controlled shapes, the resonance can only be tuned over a limited range of wavelengths.

The object of this novel IIT technology is to provide 3D nanoresonators which are free, meaning they are not fixed to any substrate and dispersible in a fluid medium, and have resonance properties tunable over a wide spectrum of wavelengths as a result of the design of the resonant structure, while being sensitive to the chemical and physical characteristics of their environment or to the presence of specific molecular species. The nanoresonators produced according to this technology have characteristics which significantly extend their range of applications, by combining the properties of design flexibility of the resonant frequency over a wide electromagnetic spectrum, typical of the prior art 2D nanoresonators, with the dispersibility properties of resonant nanoparticles. The possibility of tuning the optical properties of these nanoresonators over a wide spectrum of wavelengths, from the visible to the THz regions, enables these devices to be adapted to specific applications. Nanoresonators operating in the near infrared region can be used for diagnostic applications on living being, since the absorption of the tissues in this spectral range is fairly low (the “biological window”), while nanoresonators operating at THz frequencies can be used to study materials transparent in this region of the electromagnetic spectrum, for example some polymers. The intrinsic 3D structure of these nanoresonators has considerable advantages over a 2D structure; in fact the compact 3D structure is capable of being freely self-supporting, with no support by a substrate, without any appreciable changes in its shape and resonant frequency. At the same time, because of the possibility of diffusing a plurality of nanoresonators according to the invention in a fluid, the nanoresonators can be injected into a living organism for *in vivo* analysis as a diagnostic tool, or for detecting physiological or biochemical events, or for use in fluidic or microfluidic assays in which the fluid medium of immersion affects the overall dielectric constant of the resonant circuit, or for impregnating porous materials such as marble or stone used for works of art in investigative and diagnostic operations conducted on cultural assets.

In conclusion, the data of IIT experiments demonstrate that the 3D structured nanoresonators developed through this technology and produced by lithography on a sacrificial substrate followed by separation of the structure from the substrate and suspension in a liquid medium, have optical properties of sensitivity to the physical and chemical dispersion microenvironment, and to any chemical bonds formed by functionalization, and are therefore promising devices for use as nanosensors in a wide range of applications. Nanolithography is a versatile, "top-down" technique used to obtain 2D arrays of nanoantennas and nanoresonators anchored on a substrate. Our process extends the use of nanolithography to the production of free-standing, 3D nanostructures that can be dispersed in a liquid medium (see Figure 1).

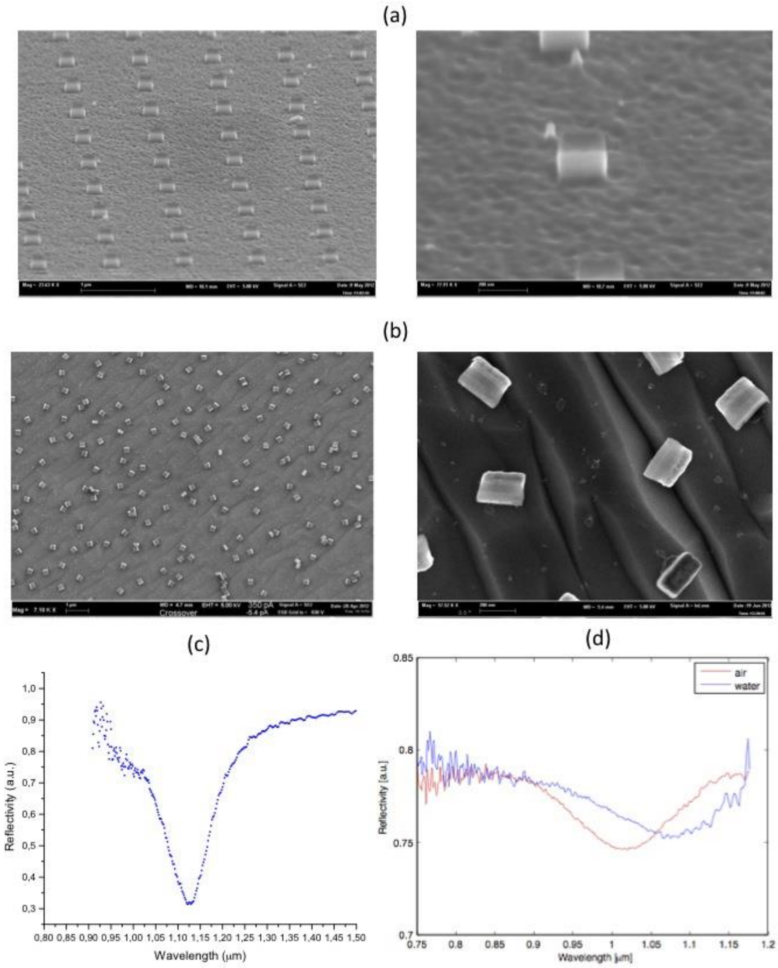

Figure 1: a) Tilted SEM images of 3D nanoresonators (two magnifications). The distance between two nanostructures is 1 µm along both directions of the plane b) SEM images (two magnifications) of 3D nanoresonators after the last wet etching process. After detachment from the substrate, most of nanoresonators tend to be capsized along the longer side. c) Optical measurement on a regular array of nanoresonators as in panel (a). d) Optical measurement on the nanoresonators 'pulled out' as in panel (b), in air and after wetting with water.

The surfaces of the nanoresonators described in the technology can also be conjugated with molecular groups which promote specific transport mechanisms, for example peptides for cell penetration, which may facilitate the internalization of the device in living cells, or which promote the bonding and accumulation of the nanoresonators in certain tissues or cell types.
The properties of the nanoresonators make it possible to use them as contrast media in a wide variety of biological and medical applications. For example, a dispersion of nanoresonators in a liquid medium, where the nanoresonators are designed to resonate in a region of the electromagnetic spectrum in which absorption by cells and tissues is fairly low, can be used as a contrast medium for medical imaging. It is expected that the use of nanoresonators developed by this technology will be able to improve the characterization of tissues and the diagnosis of numerous diseases, including cancer.
The detection capacity of nanoresonators can also be used to detect molecular interactions *in vivo* or in biological assays, in order to monitor for example gene expression, to detect proteins or enzymes in tissues and cells, or for toxicological purposes. The size of a nanoresonators is rather smaller than the size of a cell, making it possible to use the nanoresonators as intracellular probes. The internalization of the nanoresonators is possible because of their nanometric size, and can be promoted by functionalization with peptides able to penetrate the cell membranes, or other molecular groups.
The nanoresonators developed by the IIT technology can also be used for environmental applications, for example in the detection of pollutants or for the study of porous materials which can be impregnated with liquid suspension containing a set of dispersed nanoresonators.

MARKET ANALYSIS

Nanosensors are already in use in the medical diagnosis field, but are expected to see near-term commercialization in military, domestic, security and environmental monitoring applications, as well as several other areas. For the system optimization and for the detailed study of biology, nanotechnology is most commonly used.

The market for nanosensors will grow from USD 13.1 million in 2014 to USD 485 million in 2019, according to a new report by the industry analyst firm NanoMarkets, a recognized leader in industry analysis and forecasts of the sensor sector, published in April 2014 and titled *Nanosensors Market 2014*. The report explains that the demand for sensors will be driven by the latest trends in healthcare and national security needs, as well as the trend toward an Internet-of-Things (IoT). Like other sensor markets, the nanosensors market is highly fragmented and spread across many applications, including identification of hazardous, explosives, detection of biological weapons, fiber optic nanocameras, diabetes monitoring, total blood testing, detection of genetic defects, cancer detection, therapeutics, labs-on-a-chip, pollution control, detection of pesticides and organophosphates, detection of other harmful pathogens, energy storage, mass and pressure measurement, robotics, nanoelectronics and plasmonics, and applications in the transportation, construction, and beverage industry (see Exhibit 1).

Exhibit 1. Segmentation of Global Biosensors Market By Application (Medical Diagnostics, Pharma and Biotech, Food and Beverages, Environment Safety, Defense and Security and Other Applications)

Segment	Applications
Medical Diagnostics	Includes blood glucose monitoring Biosensors, blood cholesterol monitoring Biosensors, blood coagulation monitoring Biosensors, Biosensors for infection detection, DNA sensors, immunity detection Biosensors, and Biosensors for other molecular components detection and disease manifestation.
Pharma and Biotech	Includes the Biosensor used in fermentation, sterility assurance, drug analysis, drug discovery, drug delivery, and in biotech research.
Food and Beverages	Includes the Biosensors for the detection of pathogens, pesticides, allergens, toxins, heavy metals, other organic matter and poisonous substances detection in the food processing and beverage industries.
Environment Safety	Includes Biosensors for water pollution analysis, industrial emissions analysis, microbial analysis in agriculture, toxic gas analysis, and clean room monitoring.
Defense and Security	Includes Biosensors for bio-defense (biological weapon detection), explosives detection, inflammables detection, poisonous gases, DNA fingerprinting and space watch.
Other	Includes Biosensors used in molecular analysis in chemical and mining industries.

From RI Technologies - RITMIR034: Biosensors - A market Inside Report, July 2013

Nanosensors development is initially being driven by military and domestic security applications where cost is not the primary issue. Detecting small traces of toxic substances in this sector can mean the difference between life and death. The demand here is immediate, but relatively limited compared to medical and industrial segments - sales of nanosensors for detecting harmful substances will reach no more than USD 55 million by 2019 and USD 142 million in 2021. Nonetheless, nanosensors technology originally developed for military/security applications will ultimately be repurposed for industrial and medical markets. GE is already working to take nanosensors technology developed by Boeing for aerospace into a much wider range of markets.

Over the next six-eight years the largest market for nanosensors will come from the medical/healthcare sphere, with the single biggest medical application being blood sugar monitoring for diabetics. NanoMarkets projects that this application - spurred by the dramatic recent growth in the number of diabetics - will lead to nanosensors sales of USD 153 million in 2019, growing to USD 457 million in 2021. Other important medical applications for nanosensors will include total blood testing and therapeutics.

Today most IoT applications do not require nanosensors, but this will change. Nanosensors technology may reduce the cost of sensing spurring the ubiquitous sensing that lies at the core of the IoT concept. The NanoMarkets' report notes how the deployment of nanosensors may transform wireless sensor networks into "smart dust" used for both healthcare and military applications. Other IoT applications may also benefit from the sensitivity of nanosensors. One possibility is nanosensors-based networks of self-monitoring components in planes and cars and pervasive gas sensing capabilities in the chemical and power-generation industries. Also important in this context is that several companies, including IBM, are developing technologies that interface nanosensors to conventional silicon chips.

NanoMarkets believes that longer-term revenues generation from nanosensors will also emerge from a variety of uses for such sensors in microelectronics manufacturing and in the construction market. In addition, the near-term development of nanosensors will be an important enabling technology for the "Internet-of-Things" and robotics. Coverage of materials includes biological materials and inorganic nanomaterials, including graphene and quantum dots.

Nanosensors have made remarkable advances during their relatively short history, and NanoMarkets expects to see continued growth in a variety of applications. The primary forces governing the growth of nanosensors are: (1) the possibility of improved sensitivity and (2) the ability to sense multiple chemical compounds simultaneously. The most immediate opportunities are in the biomedical and healthcare industries. However, NanoMarkets also believes that longer term revenue generation will come from a much wider variety of uses for nanosensors. Several other sectors that are further behind in commercialization, but believed to have great potential for future profitability, include security, surveillance and military, environmental monitoring, food management, transportation, construction, energy storage, robotics and the Internet-of-Things (IoT). These sectors are not completely independent, since nanosensors developed for a particular purpose, such as detecting chemical contamination, may be used in many different types of applications. Growth in each sector will also influence the market as a whole, and drive the progression of research activities for components within an individual device or an entire system.

NanoMarkets believes that, in aggregate, the opportunities for nanosensors are immense, and need for small systems as analyzers and data storage entities will drive market growth. However, participants in this market must remember that nanosensors are still a new technology and, just as for sensors based on microtechnology, it will take some time for nanosensors to start earning significant revenues. Continuing progress in nanotechnology tools and increasing understanding of nanoscale phenomena will be necessary to further enhance performance of existing nanosensors and allow researchers to develop nanosensors based on novel mechanisms.

Focus 1 - Nanosensors in Healthcare and Biomedical Sector

The healthcare and biomedical sector is the largest initial market for nanosensors owing to increasing requirement for rapid, compact, accurate and portable diagnostic sensing systems. Nanosensors have the capabilities to address this requirement. Blood sensors capable of detecting multiple pathogens or chemical compounds are one such example. Point-of-care diagnostics are possible with nanosensors. The development of specialized analytical and medical diagnostic facilities across the globe is driving growth here. Moreover, nanosensors and nano-enabled integrated systems will be used in large populations in the near future for preliminary diagnosis or screening; they are portable and take less time for analysis, making them suitable for places where medical facilities are not accessible. Meanwhile, research in the field of *in vitro* nanosensors for diagnostics is progressing and there are a few products that are nearly ready for market testing. For example, researchers at Northeastern University have developed portable nanosensors for monitoring diabetes using an optical nanobiosensor. Vista Therapeutics has recently commercialized a nanowire-based biosensor (NanoBioSensor) that offers real-time monitoring of multiple cancer biomarkers in very low concentrations not achievable by macro-sensors.

However, consideration of the risks inherent in applications that impact human health will tend to impact the market in a somewhat negative way; nanomaterials have to be biocompatible and non-toxic, especially when they are used as *in-vivo* sensing applications. Toxicity issues have curtailed the use of quantum dots (QD) in the medical sector because of the cadmium content in these materials, and QDs have not so far been able to achieve their apparent potential in medical applications. Companies dealing with nanomaterials for sensors in medical applications need to consider toxicity, molecular characteristics, leachants, possible secondary reactions generating any toxic side products, and what happens when these materials degrade. Regulatory factors influence the medical market, so companies dealing in substances that do not require FDA approval are best-positioned to succeed in this market.

NanoMarkets sees compelling opportunities for nanosensors in the future to sell products not only to big industries or hospitals but also to consumers in their homes. Miniaturization has already paved the way for customization of technology and fabrication of nanobiosensors as point-of-care diagnostic tools.

Focus 2 - Food Management, Military Applications and Environmental Monitoring

Companies dealing with nanosensors, especially mass producers of nanosensors, have huge growth potential in the food management industry to improve quality control for food and beverage production, packaging, storage, and transportation. Food management is a large industry that could eventually provide significant revenue for companies that can produce high volumes of effective nanosensors. However, the market for nanosensors in food management is, however, still very much in development and is expected to grow slowly with progression in combination of microtechnology and nanotechnology. Once nanosensors firms can present proof-of-concept, demand for these products seems to materialize.

In military applications, chemical nanosensors and nanobiosensors will have considerable opportunities as security surveillance devices in detection of potential harmful, explosives, biological warfare agents, and chemicals; the sensing units can be deployed in war zones owing to their small size. Countries show great interest to make huge investments in security, and socio-economic disturbances and political unrest indirectly drives the growth of the nanosensors market. Military applications can be very demanding, however, and reliability in this sector is critical. Nanosensors for military applications require exhaustive and extensive pre-testing to calibrate sensing parameters and ensure their ability to check multiple samples accurately and quickly, which could provide barriers to entry for companies that cannot meet the military's stringent requirements.

In environmental applications, mandatory regulatory checks for waste-producing industries are driving interest in nanosensors for testing environmental samples and continued improvement in nanosensors design. In this context, there is an opportunity for nanosensors to enhance environmental safety, working as check zones for various polluting chemicals, including gases, solid particulates, and ions, along with biomolecules such as pathogenic microorganisms.

Focus 3 - Microsensors, Robotics and the Internet-of-Things (IoT)

The dramatically enhanced sensing properties of nanosensors suggest that in the longer term there are going to be significant revenue generating opportunities to expand the use of these sensors into broader areas. NanoMarkets expects that nanosensors will gain the market share from existing microsensors in the medium-to-long term. Integrated storage components containing tiny transducer chips inside the nanosensor is one such example. These chips are cell membrane penetrable and operate as "nanobots". Another example is a robust electronic sensor developed by Tel Aviv University in Israel. It contains arrays of silicon nanowires that are coated with specialized chemicals to detect dangerous explosives. This nanotechnology-based sensor is quick and highly portable and is more sensitive than macro systems in detecting minute levels of harmful chemicals. Commercial applications in robotics and the Internet-of-Things (IoT) have not yet emerged for nanosensors, but any talk of nanosensors immediately raises thoughts of these two applications. In the case of robotics this is probably because of the fact that nanotechnology was originally characterized by the concept of tiny robots engaged in fabrication of macrostructures of various kinds. IoT represents the operation of billions of sensors that would include nanosensors to make everyday environments more responsive. Some of those sensors would be nanosensors, thereby creating a new addressable market for nanosensors. Design and problem complexity have so far resulted in very few working examples of nanosensors in these applications. It will probably take a successful prototype to serve as an example in order for this sector to embrace nanosensors. Wireless sensor networks (WSN), which have an edge over traditional sensors in terms of sensing capabilities, are a promising path for nanosensors to gain entry in this space.

Collaborations

Nanosensors have made entry into the commercial sensing market through partnerships between scientists and industry partners in joint ventures. Companies like Nano Engineered Applications, LambdaGen, NanoWorld, and Vista Therapeutics are already participating in such collaborations and partnerships. These initiatives are small and localized today, but are expected to grow at a fast rate in niche sectors of security and medical industries that are relatively price-insensitive. However, in order to further expand into commercial markets, nanosensors will need to justify the initial investment for developing nanosensor-based products and their associated higher costs. Some of these businesses may be able to justify costs if nanosensors can meet technical requirements that macro sensors cannot, but very cost-sensitive markets cannot justify using nanosensors in their current state of development. Sensor developers will have to overcome the present high costs of production in order for their sensors to be used in consumer products. As is the case with any developing technology, prices will eventually go down once lifetime, usability and production yields increase sufficiently to enable economies of scale.

New Nanotechnologies for Sensors

The "top-down approach" to nanotechnology, whereby nanostructures are created, manipulated, and modified by machine, is sometimes incapable of offering complexity and economy. However, with the advancement of manufacturing processes, this approach can be extended for developing nanosensors with many such sensors created on a bulk surface. Meanwhile, the focus of synthesis of nanomaterials has increasingly shifted to other processes, principally those that use molecular self-assembly (MSA) or "bottom-up" methods. Under the right conditions, the atoms, molecules, and larger units combine strategically with one another forming self-assembled moieties such as hybridization of DNA molecules. Nucleic acid self-assembled nanostructures are going to be very important in sensing systems, particularly in biosensors for the detection of pathogenic micro-organisms, cancerous tumors and biological warfare agents. The market for these molecules at present is restricted to research activities across the globe; however, most of the dedicated laboratories are manufacturing their own molecules and are expected to grow slowly. These nanofabrication processes are a pre-requisite for designing physical nanosensors, and their development will facilitate nanosensing device preparation which had been a difficult task owing to technical limitations of fabrications. Newer classes of nanomaterials, like graphene, CNTS and their chemical derivatives, are continuously sought for improved characteristics for better sensing capabilities. There are many such materials being looked at, especially single-walled carbon nanotubes and graphene. For example, pressure nanosensors based on graphene are a promising line of research with many interesting results.

COMPETITIVE SCENARIO

While many firms involved in this market are often very small and/or only recently incorporated, NanoMarkets' report notes that some major multinationals are also involved in the nanosensors market and that they will deploy their large resources - both dollars and marketing channels - to make the nanosensors business really profitable. Key companies that are operating in the nanosensors market are reported below.

- Addison (Canada, http://addison-electronique.com/index.php/about-us)
- Affymetrix (USA, http://www.affymetrix.com/estore/)
- Agilent (USA, http://www.agilent.com/home)
- Applied Nanotech Holdings Inc. (USA, http://www.appliednanotech.net/)
- Authentix (USA, http://www.authentix.com/)
- Bangalore Genei Pvt. Ltd. (India, http://www.bangaloregenei.com)
- Bayer (Germany, http://www.bayer.com/)
- Biacore (Sweden, https://www.biacore.com/lifesciences/index.html)
- BioCrystal (UK, http://www.biocrystal.co.uk/)
- Bio-Rad (Italy, http://www.bio-rad.com)
- Boeing (USA, http://www.boeing.com/boeing/)
- Bracco SpA (Italy, http://imaging.bracco.com/it-en)
- Debiotech (Switzerland, http://www.debiotech.com/newsite/page/index.php?page=home)
- Diabetech (USA, http://www.diabetech.net/)
- Dionex Corp. (USA, http://www.dionex.com/en-us/index.html)
- Dow Corning (USA, http://www.dowcorning.com/)
- EPIR Technologies Inc. (USA, http://www.epir.com/)
- Evident Technologies (USA, http://www.evidenttech.com/)
- General Electric (USA, http://www.ge.com)
- IBM (USA, http://www.ibm.com/us/en/)
- ICx Technologies Inc. (USA, http://gs.flir.com/)
- Life Technologies (USA, https://www.lifetechnologies.com)
- LamdaGen Corp. (USA, http://lamdagen.com/)
- Lockheed Martin Corp. (USA, http://www.lockheedmartin.com/)
- Microfluidics Corp. (USA, http://www.microfluidicscorp.com/)
- Motorola (USA, http://www.motorola.com/)
- NanoCellect (USA, http://nanocellect.com/)
- Nanocor (USA, http://www.nanocor.com/)
- Nano Detection Technologies Inc. (USA, http://www.ndtbio.com/)
- Nano Engineered Applications (USA, http://www.neapplications.com/)
- Nanomix (USA, http://www.nano.com/)
- Nanoscience Diagnostics (USA, http://nanosciencediagnostics.com/Home.html)
- Nanosensors (Switzerland, http://www.nanosensors.com/)
- NanoWorld (Switzerland, http://www.nanoworld.com/)
- Naturgas (Denmark, https://www.naturgas.dk/)

- Nippon Hoso Kyokai (Japan, http://www.nhk.or.jp/english/)
- Opel (Germany, http://www.opel.com/)
- Oxonica (UK, http://www.oxonica.com/)
- PEPperPrint (Germany, http://www.pepperprint.com/high-content-peptide-microarrays/)
- PerkinElmer (Italy, http://www.perkinelmer.com/)
- pSivida (USA, http://www.psivida.com/)
- Renishaw (UK, http://www.renishaw.com/)
- Samsung (South Korea, http://www.samsung.com/)
- Sigma Aldrich (USA, http://www.sigmaaldrich.com/)
- Ted Pella Inc. (USA, http://www.tedpella.com/)
- Texas Instruments Inc. (USA, http://www.ti.com/)
- Thermo Fischer Scientific Inc. (USA, http://www.thermofisher.com/en/home.html)
- Specialized Imaging (UK, http://specialised-imaging.com/)
- VASEMA (Austria, http://www.vasema.com/index.php?lang=en)
- Vista Therapeutics (USA, http://www.vistatherapeutics.org/)

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