TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

28th March 2014

1. FLEXIBLE ANTENNA FOR FLEXIBLE WEARABLE SENSORS

Printed and flexible electronics have gained a lot of traction in recent years. One of the key drivers for this is the potential of wearable electronics, which benefits from flexible characteristics. Wearable electronics such as sensors can collect information regarding various parameters such as activity or health parameters. But for proliferation of these devices, wireless transmission of data is required. The antenna, which converts electric power into radio waves, is a key component in such wireless systems that use a radio transmitter or receiver.

Researchers at North Carolina State University, USA, have developed a stretchable antenna, which can be integrated with flexible and wearable sensors to enable wireless connectivity. The researchers envisioned a stretchable antenna, which returns to its original state once the stress is removed. This is because wearable sensors are exposed to a lot of stress as the user is constantly in motion. Realizing this, the researchers used silver nanowires and polymer materials. They used a stencil for applying silver nanowires in specific patterns. Once the pattern was created, liquid polymer was poured on it, and left to set. This created an elastic material with the nanowires embedded in it. The nanowire patterns constitutes the radiating element of the antenna. By altering the shape and size of these elements the frequency of operation of the antenna can be controlled. This part of the antenna was then grounded using continuous silver nanowires embedded in the same polymer material.

When the antenna is subjected to stress, its frequency changes but remains within a certain bandwidth. This indicates that the antenna will be able to communicate wirelessly with remote sensors even when stretched. After the stress is removed, the antenna returns to its original state and continues to function. Moreover the researchers noted that the change in frequency due to strain follows an almost linear pattern. This property can be used to utilize the antenna as a strain sensor itself. The technique used by the researchers is very simple and it will be easy to scale up the process. Since wearable electronics, particularly for health and wellness, would require wireless data transmission, this antenna can be potentially used in a variety of products. Using the technique antennas with complex structures can also be developed having multi-layer structures.

The researchers have published their findings, entitled "Stretchable and Reversibly Deformable Radio Frequency Antennas Based on Silver Nanowires," online in the journal ACS Applied Materials & Interfaces on March 4, 2014. The research was supported in part by the US National Science Foundation (NSF). It is estimated that commercial devices employing the developed antenna technology would have an year of impact around 2019.

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2. LED-BASED RANGING SENSOR FOR INDUSTRIAL USAGE

In the industrial setting, object detection and ranging allows for such functions as locating and tracking objects. Key technologies currently used for such functions include vision sensors, ultrasonic sensors, active or passive infrared sensors, radar (radio detection and ranging), and laser scanners/lidar(light detection and ranging). These systems can provide accurate results under favorable ambient conditions but can possess certain challenges. For instance, vision-based systemscan fail to be accurate under harsh weather conditions such as snow, rain, or fog. Laser-based systems can be highly accurate, but are generally very expensive. Most scanning systems also comprise of multiple moving parts, which are prone to damage in rough conditions.

Canada-based LeddarTech Inc., addresses these challenges by using light-emitting diode (LED)-based ranging sensors. The company's IS16 Industrial Leddar sensor can enable robust operation under difficult weather conditions, including fog, rain, snow, and low-ambient light. The sensor has an accuracy of about 6 centimeters, which is suitable for monitoring objects on conveyor belts, crane operations, loading dock vehicle positioning, collision avoidance, and vehicle detection at barrier gates among others.

The sensor emits infrared light and uses time of flight principle to detect, locate, and measure objects. It does not contain any moving parts, which make the system immune to damages form rough environmental conditions. Because of this, the sensor does not require regular yearly maintenance and has a very high mean time between failures (MTBF) of about 17 years.

The sensor can be configured to provide information from 16 zones inside the field of view and provides a detection range up to 50 meters. The IS 16 measures only 136 mm x 86 mm x 70 mm, and weighs about 430 gm, which makes it easy to install into small space constraints. The IS16 comes in a robust IP67 enclosure. By having up to 16 different zones of detection, the sensor is able to cater to various applications. It also allows users to specify zones for detection, which enables flexibility in operation. The sensor provides two detection areas (based on distance) for each of the 16 zones. This can be useful for applications such as vehicle detection when the sidewalk comes in the field of view. In such case the sensor will not trigger a positive reading when objects (such as pedestrians) are detected in the sidewalk.

The technology behind the working of the sensor was initially developed at the Institut National d'Optique (INO), Canada, and is owned by LeddarTech Inc. The company’s technology has been integrated into various products.

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3. CONSORTIUM TO DEVELOP MINIATURIZED INDOOR AIR QUALITY MONITORING SOLUTION

Air quality monitoring is an important way of maintaining a healthy environment in buildings, homes, and vehicles. Indoor air quality has been linked to causing various discomforts for people, which include fatigue, throat irritation, dizziness, and headaches among others. Air quality can be gauged by measuring the concentration of various gases, such as carbon dioxide as well as volatile organic compounds (VOCs). Automated HVAC (heating, ventilation, and air conditioning) systems use carbon dioxide sensors for demand-controlled ventilation (DCV), which is used to modulate outside air ventilation based on real-time occupancy of a space. DCV can reduce unnecessary over-ventilation. Carbon dioxide can provide a good indication of human metabolic activity and, therefore, can be used as a tracer for human bioeffluents. Poor air quality associated with elevated levels of carbon dioxide can indicate accumulation of other indoor contaminants. Moreover, the presence of VOCs, even in very low concentrations such as parts per billion (ppb) can lead to poor air quality. VOCs, such as acetone, heptane, formaldehyde, which can be emitted from such sources as building materials, furnishings, or office equipment, can affect human health in an indoor environment. By detecting pollutants, VOC sensors can help optimize ventilation to provide high air quality and economical utility costs. Since the potential benefits of employing indoor air quality monitoring systems are great, there is a need for low cost and reliable solutions.

The European Commission has launched a project to develop such low-cost air quality monitoring sensors. The project, titled IAQSense (Nanotechnoloogy-based sensors for environmental monitoring), which runs from September 2013-August 2016, aims at developing nanotechnology-based sensors for detecting VOCs and other hazardous components present in an indoor environment. The sensors will be able to monitor chemical and bio contamination. The system will include a polar ionization detector, a spectrometer on a chip, and a piezo-cantilever balance-based trace molecule detector. It will also consist of integrated electronics that will employ pattern recognition techniques for swift detection of contaminants. The main objectives of the developed system will be to detect and distinguish VOCs down to ppb levels, biomolecules down to ppb levels, and narcotics down to parts per trillion (ppt) levels.

The IAQSense project partners include small and medium enterprises (SMEs), research organizations, and industrial participants. These are CEA-INES, Efficience Marketing, ID-MOS, and EELEO (France); NanoAnalytik and ISL (Germany); Microsystems Ltd. and Fabless CET (Bulgaria); FSRM (Switzerland); and Acciona Infraestructuras (Spain). The EU's contribution toward the project was €3.5 million (about US$ 4.8 million at current exchange rate) out of €4.9 million (aboutUS $ 6.7 Million at current exchange rate). Even though the main targeted application is indoor air quality monitoring, the sensor technology can be explored for such applications as automotive sensing as well as smartphone connected sensors. In indoor applications, the sensor can enable higher energy savings and comfort by equipping HVAC systems and building management systems with more real-time intelligence.

The consortium also aims at developing the sensor compatible with mass manufacturing techniques that will enable low-cost final products. The development is expected to have a high impact on the megatrend of 'Health, Wellness and Well-being.'

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4. PATENT ANALYSIS OF PRINTED SENSORS

Advancements in printed sensors are driving opportunities for cost-efficient production of sensors in volume. Sensors, such as metal oxide gas sensors,, have been screen printed on a ceramic substrate. Newer printed sensors currently use specialized inks that are printed on plastic substrates. Since the base material is plastic, the sensors produced are flexible, thin, and lightweight. The inks used for printing are of three types--conductors, resistors, and dielectrics. Printing techniques include flexography, gravure printing, and offset printing, as well as inkjet and screen printing. However, there has been interest in employing newer technologies such as atomic layer deposition (ALD), extreme ultraviolet lithography (EUV), and aerosol jet printing, for printing sensors.

Key promising application areas of printed sensors include healthcare, smart packaging, wearable electronics, consumer electronics, defense and security. Since printed sensors are extremely inexpensive to manufacture, they can enable the proliferation of low cost disposable sensors in the field of healthcare. Patents published in the field of printed sensors indicate a focus on developing specific sensors, such as temperature sensors,touch sensors, force sensors, gas sensors, humidity sensors, level sensors using printing processes.

PATENT TITLE	PUBLICATION DATE / NUMBER	APPLICANT/ ASSIGNEE	INVENTORS	ABSTRACT
Printed Stretch Sensor	06.02.2014; US 20140035603	Ray Elton T.	Ray Elton T.	Disclosed is a patterned article comprising: (1) a deformable nonconductive substrate; (2) an imagewise pattern thereon of a conductive stretchable ink; and (3) an external circuit connecting the imagewise pattern, the external circuit being capable of measuring the electrical resistance across regions of the deformable nonconductive substrate and determining the degree of deformation thereof.
PRINTED TEMPERATURE SENSOR	24.07.2013; EP 2616784	PST SENSORS PTY LTD	BRITTON DAVID THOMAS	A method of producing a temperature sensing device is provided. The method includes forming at least one silicon layer and at least one electrode or contact to define a thermistor structure. At least the silicon layer is formed by printing, and at least one of the silicon layer and the electrode or contact is supported by a substrate during printing thereof. Preferably, the electrodes or contacts are formed by printing, using an ink comprising silicon particles having a size in the range 10 nanometres to 100 micrometres, and a liquid vehicle composed of a binder and a suitable solvent. In some embodiments the substrate is an object the temperature of which is to be measured. Instead, the substrate may be a template, may be sacrificial, or may be a flexible or rigid material. Various device geometries are disclosed.
Printed Gas Sensor	23.05.2013; US 20130126069	KWJ Engineering, Inc.	Stetter Joseph R.	A printed gas sensor is disclosed. The sensor may include a porous substrate, an electrode layer, a liquid or gel electrolyte layer, and an encapsulation layer. The electrode layer comprises two or more electrodes that are formed on one side of the porous substrate. The liquid or gel electrolyte layer is in electrolytic contact with the two or more electrodes. The encapsulation layer encapsulates the electrode layer and electrolyte

				layer thereby forming an integrated structure with the porous substrate.
METHOD OF MANUFACTURING A RESISTIVE TOUCH SENSOR CIRCUIT BY FLEXOGRAPHIC PRINTING	02.05.2013; WO/2013/063034	UNIPIXEL DISPLAYS, INC.	PETCAVICH, Robert, J.	Method of manufacturing a resistive touch sensor circuit using a roll to roll process to print microscopic patterns on a single side of at least one flexible dielectric substrate using a plurality of flexo-masters to print the microscopic patterns which are then plated to form conductive microscopic patterns.
METHOD FOR MANUFACTURING A PRINTING RF HUMIDITY SENSOR TO BE USED IN BABY DIAPER CAPABLE OF MANUFACTURED WITH A ROLL TO ROLL PRINTING METHOD	20.06.2012; KR 1020120064775	INDUSTRY-ACADEMY COOPERATION CORPS OF SUNCHON NATIONAL UNIVERSITY	CHO, GYOU JIN	PURPOSE: A method for manufacturing a printing RF humidity sensor is provided to minimize production costs by directly printing a sensor. CONSTITUTION: An RF humidity sensor is manufactured by a roll to roll printing method. The RF humidity sensor prints by using gravure, offset, rotary screen, flexo, and ink jet. A humidity sensor material includes PEDOT(Poly 3,4-EthyleneDioxyThiophene), PEO(Poly Ethylene Oxide), PEDOT+PEO, PEDOT+TiO2(Titanium-Dioxide), and polypyrrole +TiO2. The RF humidity sensor activates in the humidity of 60%-70%.
PRINTED FORCE SENSOR WITHIN A TOUCH SCREEN	20.06.2012; EP 2465019	MOTOROLA MOBILITY INC	CRANFILL DAVID	A quantum tunneling composite, or other material exhibiting changing electrical or magnetic properties as force on the material is increased, can be located within a force concentrator integrated into traditional touch screen layers to sense force applied on the touch screen. The force concentrator can be a protrusion from the layer planes of the layers in a traditional touch screen and can be formed, at least in part, from printed elements. The amount of protrusion of the force concentrator can be adjusted through multi-pass printing and thicker deposit printing. The force concentrator can also have optically clear adhesive layered over it. The force-sensitive material can be optionally pre-loaded so as to operate within a substantially linear feedback range. A sensing mechanism can be configured to detect changes in force at multiple locations or to detect the application of force irrespective of location.

Low manufacturing cost printed ink liquid level sensors	16.02.2010; US 7661307	MILONE CHRISTOPHER J	MILONE CHRISTOPHER J	First and second elongated flexible insulated substrates have patterns of resistive liquid level sensor sections along the substrate lengths, each pattern comprising printable resistive ink of the same resistivity (ohms-squared), wherein the patterns can be simultaneously printed upon each substrate to save manufacturing costs. The substrates can be separated by an elongated spacer that couples longitudinal edges of the facing substrates together with an appropriate adhesive. Alternatively, the facing substrates can be folded along a central fold line to form a first longitudinal edge and adhesively joined along a second longitudinal edge opposite the first longitudinal edge. The flexibility of the substrates enables the low manufacturing cost liquid level sensors to be positioned in for example in a highly irregularly shaped vehicle fuel tank. Also, sections of varying lengths to be cut from the rolls on demand by users to form customized lengths of liquid level sensors for numerous applications.

Exhibit 1 lists some of the key patents related to printed sensors.

Picture Credit: WIPO/Frost & Sullivan

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