TECHNICAL INSIGHTS

SENSOR

TECHNOLOGY ALERT

16th May 2014

1. DETECTION OF EXPLOSIVES USING OPTICAL FIBERS

CBRNE (chemical, biological, radiological, nuclear, explosives) detection technology is one of the key technologies used to counter the threat of terrorism and war. Among these, threatening explosives, or improvised explosive devices (IEDs), are a common, virulent type. Traditionally, IEDs have used metal casings that make detection easy by using metal detectors. However, when metals are not used, the detection procedure becomes challenging,since there is a need to detect the explosive material. In the case of underwater mines and ordnance, sensing of explosives, such as dinitrotoluene (DNT), trinitrotoluene (TNT), and picric acid (PA), is important. These nitroaromatic explosives can be detected using technologies such as ion mobility spectrometry (IMS)(although IMS can have difficulty with low vapor pressure explosives such s RDX and PETN), Raman spectroscopy, terahertz imaging, and fluorescence quenching. Though fluorescence quenching technology using novel sensing materials could provide promise for fast, highly sensitive detection of explosives, it may require large volumes of the sample.

Researchers at The University of Adelaide Australia have developed an optical fiber sensor that uses the fluorescence quenching technology to detect low-concentration explosives within a short analysis time. The system consists of a polymer, MEH-PPV (poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene]), which is coated on the optical fibers. When illuminated with green laser light, the polymer emits red light. In the presence of explosives, the amount of red light emitted is reduced, which gives an easy indication of the concentration of explosive present in the sample. The sample is mixed in a tetrahydrofuran (THF) solvent before being inserted into the fiber. It is inserted into the fiber through minute holes, and the principle of capillary action pushes the sample through the fiber. A major advantage of this system is that it can detect the explosives from very little amount of sample. In a sample

volume of just 27 nanoliters, the sensor was able to detect low concentrations down to 6.3 parts per million (ppm).

The use of a fiber optic system provides advantages that include portability, flexibility, low-cost, and the ability to access remote areas. Since the detection time is only a few minutes, samples can be tested on location to screen whether the area is contaminated or not. It can also be used in forensics to determine whether explosives were present in the scene of investigation.

The researchers have published their findings in a paper titled 'Explosives detection by fluorescence quenching of conjugated polymers in suspended core optical fibers' in the August 2014 volume of the journal, Sensors and Actuators B: Chemical. The research was carried out in collaboration with the Defence Science and Technology Organisation (DSTO) of Australia. The sensor, when commercialized, will be able to enhance CBRNE detection on ground, as well as, under water. The year of impact for this sensor is expected to be around 2018.

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2. BACKSIDE ILLUMINATED IMAGE SENSOR FOR AUTOMOTIVE APPLICATIONS

The demand for enhanced safety for automobile passengers and pedestrians is driving the growth of advanced driver assistance systems (ADAS). ADAS, such as, lane departure warning, blind spot detection, night vision, obstacle detection and avoidance, adaptive cruise control, and parking assistance, are being increasingly integrated into automobiles at factory settings and also being made available as aftermarket solutions. The various sensor technologies used in ADAS include ultrasonic sensing, radio detection and ranging (radar), light detection and ranging (lidar), infrared sensing, and vision sensing. Image sensors have the potential to be increasingly used in multiple ADAS applications (such as lane departure warning, parking assistance, as well as, fatigue monitoring) and are thus a most promising ADS technology.

US-based OmniVison Technologies Inc. has recently developed an image sensor--OV10640--for ADAS applications using backside illumination (BSI) technology. The sensor also delivers a high dynamic range of up to 120 decibels (dB) and has a companion chip--OV490--which enables high-quality processing of images and video. The sensor has a resolution of 1.3 mega pixels and can capture videos at a rate of up to 60 frames per second. Each pixel of the sensor measures 4.2 micrometers and the sensor has an imaging area of (5410 × 4570) micrometers. The sensor uses compact chip scale packaging technology, which limits the footprint of the sensor.

BSI differs from the traditional front side illumination (FSI) technology in the way pixels are placed inside the sensing chip. In OmniVision's BSI technology, OmniBSI, the color filters and micro lenses are fitted at the backside of the pixels. The light thus enters from the back side of the sensor and hence the name backside illumination. Using BSI, the light has a more direct path to the pixel, with lesser interference from dielectric and metal layers as in the case of FSI sensors. This enables the sensors to have a better fill factor and results in more information being captured.

Automotive applications require image sensors to have a high dynamic range because the sensors are often exposed to diverse lighting conditions in the same scene. These scenarios commonly occur when light from sources such as headlights, sunlight, and reflected light fall directly on the lens of the camera. In these conditions, the image tends to get either overexposed or underexposed, resulting in a washout or dark image respectively. In the absence of high dynamic range, the sensor fails to capture details, which can lead to errors in critical applications and compromise passenger safety.

OmniVision partners with key semiconductor foundry provider Taiwan Semiconductor Manufacturing Company Limited (TSMC). The OV10640 is currently being sampled and full production is expected to start by the end of 2014.

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3. WIRELESS PARKING ASSISTANCE SENSOR SYSTEM

Safety is a primary area of concern in designing automobiles—safety of the passengers, as well as, of road users and property. Many accidents occur while vehicles move backward, especially when people or objects are present in a blind spot. The US National Highway Traffic and Safety Administration (NHTSA) has reported that people are injured annually by vehicles backing up. It has been noted in the recent past that more than 6,000 blind spots are areas that drivers are not able to see. The problems arising with blind spots at the rear of a vehicle are more pronounced in case of trucks and trailers. Such vehicles are larger than passenger vehicles and rear view mirrors may not be effective as the truck's body blocks vision.

Back up assistance systems generally use vision-based sensors or ultrasonic sensors that either provide a visual aid or provide a warning to drivers about obstacles present near the vehicle.

US-based Mobile Awareness LLC provides sensing systems that assist drivers in preventing collisions and avoiding injuries. The company's SenseStat wireless obstacle detection system uses multiple ultrasonic sensors to detect obstacles at the rear end of commercial vehicles such as lift trucks, single unit trucks, construction vehicles, and trucks with trailers.

Ultrasonic sensors are active sensors that emit an acoustic signal and detect the distance from the sensor to the object based on the time it takes for the sound wave to travel to the target and back.

The SenseStat system comprises four sensors that provide information on the closest obstacle to the vehicle. By having four separate sensors, it becomes possible to monitor four different zones. The sensors can detect obstacles up to eight feet from the vehicle, which provides ample time and warning to the driver. The warnings are transmitted to the driver through audible and visual means. The visual display consists of a light emitting diode (LED) monitor that projects actual distance information of the closest obstacle, as well as, information about the presence of obstacles in the four different zones. In case of trailers with hanging objects, it is possible to adjust the zero point up to 32 inches. This feature allows more accurate assistance while backing up and parking. The system has an accuracy of one inch, which is beneficial when operating vehicles such as a tractor.

The sensors, as well as, the wireless electronic control unit (ECU) are waterproof and can be mounted easily on the rear end of the trucks. The installation process is easy and can be done within one hour for most vehicles. Using digitally encoded wireless transmission technology, signals from the ECU are sent to the dashboard mounted LED monitor. The sensors are suitable for use in harsh environments and use easily attachable rubber sleeves for protection. The system has an operating temperature range of -30 degrees Celsius to + 80 degrees C, which makes it suitable for varied environments.

The SenseStat system provides advanced safety to large vehicles by helping to prevent unwanted accidents and damage to people or property. As an aftermarket product, the sensor system will benefit commercial vehicles in reducing accidents.

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4. RECENT PATENTS IN THE FIELD OF MEMS MICROPHONES

Microphones convert sound energy (or pressure waves in the air) into an electrical signal. Microphones are used in a variety of devices, such as telephones, mobile phones, computers, voice recorders, and video cameras. Microphones tend to be based on the principle of electromagnetic induction, piezoelectricity, or capacitance changes due to vibrations in air pressure.

Micro-electromechanical system (MEMS)-based microphones consist of a diaphragm, which is fabricated on the silicon chip. MEMS microphones tend to be capacitive sensing devices. Some of these devices also consist of on-board analog-to-digital converters. This helps OEMs (original equipment manufacturers) for devices such as smart phones and tablets to integrate the microphone into their products. MEMS microphones have high reliability and high tolerance to mechanical vibrations, which are key driving factors for their adoption across various industries. Other advantages of MEMS microphones include small size, low power, as well as improvements in signal-to-noise ratio (SNR). MEMS microphones, which have impacted the smart phone arena as well as other consumer electronics, are being increasingly adopted into new

applications such as voice enabled gaming, medical telemetry, automotive voice systems, and so on.

Recent patents in this field indicate a focus on improving the SNR by reducing noise elements. There is also an effort to improve the performance of these MEMS devices in conditions where the microphone package can be subject to stress.

Exhibit 1 lists some of the recent published patents in the field of MEMS microphones.

PATENT TITLE	PUBLICATION DATE / NUMBER	ASSIGNEE	INVENTORS	ABSTRACT
PACKAGED MICROPHONE SYSTEM WITH INTEGRATED PASSIVE DEVICE DIE	24.04.2014; WO/2014/062305	ANALOG DEVICES, INC.	BOLOGNIA, David	A transducer system (17), has a package (38) forming an interior chamber (50), and a MEMS transducer (42), e.g., a MEMS microphone, secured within the interior chamber (50). The package (38) forms an aperture (52) for permitting acoustic access to the interior of the chamber (50) and thus, the MEMS transducer (42). The system (17) also has two dies (44, 46); namely, the system (17) has a primary circuit die (44) within the interior chamber (50), and an integrated passive device die (46) electrically connected with the primary circuit die (44). The primary circuit die (44) is electrically connected with the MEMS transducer (42) and has at least one active circuit element.
EMBEDDED CIRCUIT IN A MEMS DEVICE	03.04.2014; WO/2014/052559	KNOWLES ELECTRONICS, LLC	VOS, Sandra F.	A Microelectromechanical System (MEMS) microphone includes a printed circuit board, a MEMS die, and an integrated circuit. The MEMS die disposed on a top surface of the printed circuit board. The integrated circuit is disposed at least partially within the printed circuit board and produces at least one output signal. The at least one output signal of the integrated circuit is routed directly into at least one conductor to access pads at the printed circuit board. The access pads are disposed on a bottom surface of the printed circuit board that is opposite the top surface. The integrated circuit includes conductive pads and an interface layer is disposed between the conductive pads of the integrated circuit and the printed circuit board.

PATENT TITLE	PUBLICATION DATE / NUMBER	ASSIGNEE	INVENTORS	ABSTRACT
Volumetric Measurement Device, System and Method	27.03.2014; US20140083201	DEKA Products Limited Partnership	Lanier, JR. Gregory R.	An acoustic volume sensing device is disclosed. The device includes a housing comprising a reference volume chamber and a variable volume chamber, the reference volume chamber and the variable volume chamber connected by a resonant port, a first MEMS microphone located in acoustic relation to the variable volume chamber, a second MEMS microphone located in acoustic relation to the reference volume chamber, a MEMS speaker located in acoustic relation to the reference volume chamber, and a circuit board in electric connection with the first and second MEMS microphones and the MEMS speaker.
MEMS MICROPHONE	27.03.2014; US20140084395	Sparks Andrew	Sparks Andrew	Mechanical resonating structures, as well as related devices and methods of manufacture. The mechanical resonating structures can be microphones, each including a diaphragm and a piezoelectric stack. The diaphragm can have one or more openings formed therethrough to enable the determination of an acoustic pressure being applied to the diaphragm through signals emitted by the piezoelectric stack.
MICRO ELECTRO MECHANICAL SYSTEM (MEMS) MICROPHONE AND FABRICATION METHOD THEREOF	27.03.2014; US20140084394	Electronics and Telecommunications Research Institute	JE Chang Han	Provided is a structure for improving performance of a micro electro mechanical system (MEMS) microphone by preventing deformation from occurring due to a residual stress and a package stress of a membrane and by decreasing membrane rigidity. A MEMS microphone according to the present disclosure includes a backplate formed on a substrate, an insulating layer formed on the substrate to surround the backplate; a membrane formed to be separate from above the backplate by a predetermined interval; a membrane supporting portion configured to connect the membrane to the substrate; and a buffering portion formed in a double spring structure between the membrane and the membrane supporting portion.

PATENT TITLE	PUBLICATION DATE / NUMBER	ASSIGNEE	INVENTORS	ABSTRACT
Microphone with Programmable Frequency Response	27.03.2014; US20140086433	ANALOG DEVICES, INC.	Josefsson Olafur Mar	Methods and apparatus automatically cancel or attenuate an unwanted signal (such as low frequencies from wind buffets) from, and/or control frequency response of, a condenser microphone, or control the effective condenser microphone sensitivity before the signal reaches an ASIC or other processing circuit. As a result, the maximum amplitude signal seen by the processing circuit is limited, thereby preventing overloading the input of the processing circuit. Remaining (wanted) frequencies can be appropriately amplified to reduce the noise burden on further processing circuits. A corrective signal is applied to a bias terminal of the condenser microphone to cancel the unwanted signal. Optionally or alternatively, a controllable impedance is connected to a line that carries the signal generated by the MEMS microphone, so as to attenuate unwanted portions of the signal.
MEMS MICROPHONE USING NOISE FILTER	20.03.2014; US20140079254	RESEARCH INSTITUTE ELECTRONICS AND TELECOMMUNICATIONS	KIM Yi-Gyeong	An MEMS microphone is provided which includes a reference voltage/current generator configured to generate a DC reference voltage and a reference current; a first noise filter configured to remove a noise of the DC reference voltage; a voltage booster configured to generate a sensor bias voltage using the DC reference voltage the noise of which is removed; a microphone sensor configured to receive the sensor bias voltage and to generate an output value based on a variation in a sound pressure; a bias circuit configured to receive the reference current to generate a bias voltage; and a signal amplification unit configured to receive the bias voltage and the output value of the microphone sensor to amplify the output value. The first noise filter comprises an impedance circuit; a capacitor circuit connected to a output node of the impedance circuit; and a switch connected to both ends of the impedance circuit.

Exhibit 1 lists some of the recent published patents in the field of MEMS microphones.

Picture Credit: USPTO/Frost & Sullivan

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