World's Lowest Power & Fastest Response NDIR CO_2 Sensors

*Smart*IR CO_2 Sensing – Improving our quality of life

With the advent of the IoT or the internet of everything, we are inherently becoming more coupled with our world. Indeed, we can improve the quality of life, save power, enhance our security and overall productivity by connecting more effectively with our real world presence. Gases have a huge impact on us and our environment. We immediately think of Oxygen as our life-sustaining gas and have become very aware of carbon dioxide (CO_2) over the last 30 years or so as the "villain in the sky". However, CO_2 plays a large, positive and varied role in our day-to-day lives and the monitoring of CO_2 has many social and economic benefits. This White Paper discusses some of the application areas for smart CO_2 sensing and the leading semiconductor-based technology, developed by Gas Sensing Solutions (GSS) which is already being employed in these applications.

*Smart*IR CO_2 sensing – helping to feed the world

Horticulture is a key market area which can benefit from CO_2 management. The productivity of industrial growing enclosures can be significantly enhanced by monitoring and controlling the concentration of CO_2. Multiple crop cycles can be achieved by optimal temperature, light and CO_2 control. Using this technique, overall plant growth productivity can be improved up to 40%.

Produce transportation is another area where CO_2 sensing can significantly reduce wastage and help to ensure the product reaches its destination in peak condition. A myriad of foods are now exported and imported globally and in many cases have to travel thousands of miles in containers. The natural ripening process of these foods, such as bananas, can be accelerated or delayed by monitoring and adjusting the level of CO_2 accordingly.

Other associated food processing applications include individual, quick freezing of small food items with cryogenic CO_2 gas to lock in the moisture, shape and freshness. Carbon dioxide is widely used in modified-atmosphere packaging to prolong the shelf life of food where a decrease in its concentration can signify leakage in a package. Freshness and safety of modified atmosphere food packages can be determined by detection of CO_2 concentrations.

*Smart*IR CO_2 sensing – breath analysis for health

Patient monitoring is another key application for CO_2 sensing. Capnography involves monitoring the concentration or partial pressure of CO_2 in the respiratory gases. Its main development has been as a monitoring tool for use during anaesthesia and intensive care. The output can be presented as a graph of expired CO_2 volume plotted against time. Perturbations in respiratory rate/volume of an unwell person are a key early warning of physiological change.

Traditionally, hospitals monitor respiratory rate and volume during patient recovery using a nasal cannula: this device is physically clumsy and uncomfortable. A potentially non-invasive, battery powered, portable, wireless CO_2 sensor performing the same task offers effective deployment in the home environment during the recovery process. Moreover, the GSS technology provides a means of inherent, high rate sampling, enabling temporal characteristic of exhaled CO_2 to be measured in real time. This provides a diagnostic and management tool for a wide variety of chronic respiratory conditions.

Similarly, this *Smart*IR technology can be applied to a wide variety of health related applications which include, for example, sports fitness, baby monitoring and sleep disorder management.

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*Smart*IR CO_2 sensing – keeping us safe on the road

The World Health Organization's Global Status Report on Road Safety 2013 estimates 1.24 million traffic deaths a year. Undoubtedly, this alarming fatality figure is due in part to driver fatigue and distraction. Whilst we wait for the advent of the perfectly safe, autonomous vehicle, we are going to have to live with the defects of the human driver! Much research is currently underway in the area of driver distraction and how it can be monitored and possibly prevented. Driver drowsiness is something we have all probably experienced at some stage in our driving career. Current automotive air conditioning systems manage temperature; however, this alone does not help to relieve driver drowsiness contributed to by CO_2 concentration. New generation, automotive air management systems are being developed which will trigger airflow, based on in-car CO_2 concentration and not just temperature.

GSS on BBC One Show: https://www.youtube.com/watch?v=bNXup6E7P1g

There is yet another application for CO_2 detection in cars which relates to the monitoring of the air conditioning unit itself. With increasing legislation to reduce the usage of hydrofluorocarbon (HFC) in cooling plants, there is a move to use CO_2 as the refrigerant gas. Whilst CO_2 is the best known contributor to global warming, it is over 1000 times less potent than HFC based gases. Unlike CFC's and HFC's, carbon dioxide has no detrimental effect on the ozone layer, so replacing HFC's with CO_2 in refrigeration systems has a double benefit for the environment. Air conditioning systems do leak on occasion and *Smart*IR sensing technology can be applied to this problem.

*Smart*IR CO_2 sensing – keeping us alert!

A further and perhaps obvious application for CO_2 detection is in the home, our schools and other public areas. Conventional heating, ventilation and air conditioning systems (HVAC) are focused on temperature control alone; however, modern indoor air quality (IAQ) equipment will include a CO_2 detection component. CO_2 is an insidious gas, therefore changes in concentration are difficult for humans to recognize. It has a molecular weight of 44 which makes it heavier than air. Typically, in low concentrations <1000ppm CO_2 is a safe gas; however, prolonged exposure at moderate levels >5000ppm can lead to a range of health-related problems, such as sick building syndrome, causing fatigue like symptoms.

For example, in a classroom environment, students are initially attentive; yet, with every breath, they expel a stream of CO_2 which is diffused into the classroom. Gradually, as the students encounter rising levels of CO_2, they experience lethargy and drowsiness, leading to reduced performance and concentration. The detrimental effects of CO_2 in an educational setting such as a classroom or lecture theatre are the driving force behind current and emerging legislation [Building Bulletin 101 Version 4.1].

*Smart*IR CO_2 sensing – reducing our carbon footprint

Commercial buildings are responsible for at least 40% of the world's total energy consumption, yet, it is estimated that 96% of existing building stock currently do not have effective building energy management systems in place. The use of Demand Controlled Ventilation (DCV) with CO_2 sensing provides a route to achieving significant global energy savings.

Current deployment and powering of carbon dioxide sensors into buildings for Indoor Air Quality (IAQ) and DCV is normally through a wired connection to the building's electrical supply. However, the market demand for autonomous, wireless CO_2 sensors is accelerating due to the ease of installation and overall lower cost of maintenance.

*Smart*IR CO_2 sensing – saving our environment

In 2014, a total of 5,620 wildfires engulfed the state of California, leaving a devastating legacy. The fires burned around 631,434 acres of land, caused 2 fatalities, injured 146 and amassed damage costs of $184.02 million. In dry and hot climates, such as California, wildfires are a ubiquitous threat to human life, the environment and infrastructure.

Aside from preventive solutions, the early detection of wildfires is the only way to avoid tragic loss of life and minimise irrevocable damage. Measuring CO_2, along with temperature, humidity and atmospheric pressure can provide an early indication of the presence of fire. In addition to current methods of fire detection, the deployment of GSS *Smart*IR technology offers another way of potentially detecting incidents of fire before they become impossible to control.

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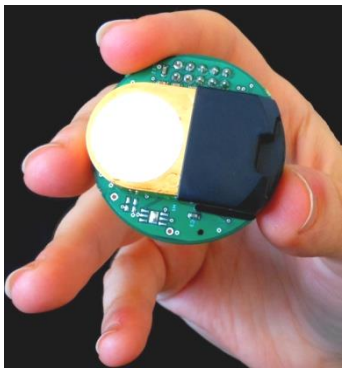
*Smart*IR CO_2 sensing – the technology behind the sensor



So far we have discussed some of the ever increasing applications for *Smart*IR CO_2 sensing. Now let's turn our attention to the leadership technology developed by GSS to enable these hugely successful sensors.

GSS sensors are based on the NDIR (non-dispersive infrared) optical method of detecting gases. Many gases absorb specific wavelengths of infra-red light. This is due to the gas molecules absorbing energy by physically vibrating when stimulated by radiation. It is therefore possible to calculate the gas concentration by passing light through a defined optical path and measuring how much light is absorbed at the specific wavelength absorbed by the gas. The commonly used wavelength for CO_2 is 4.26µm which is strongly absorbed by CO_2 but not absorbed at all by other commonly found gases or by water vapour.

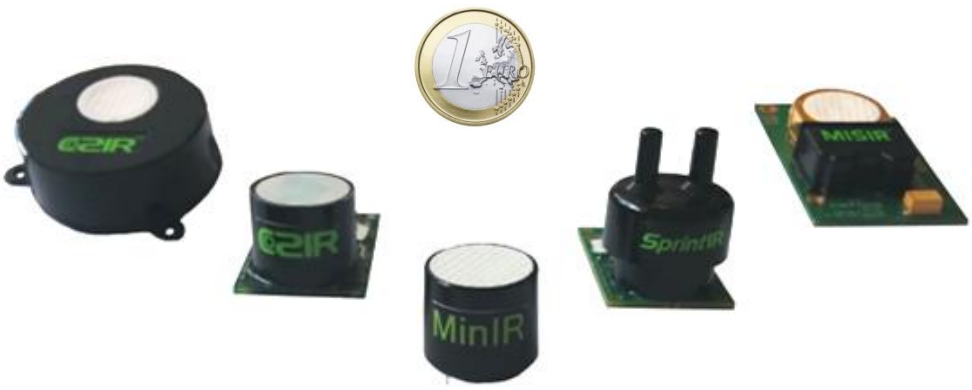
The GSS *Smart*IR low power consumption NDIR CO_2 gas sensors are based on mid-infrared, solid state, light emitting diode (LED) and photodiode (PD) technology. LEDs offer the advantage of high source emittance, fast modulation rates, longevity and room temperature operation with no burn-in and are more cost effective than laser diodes for deployment in practical gas sensors. Specific performance benefits include low power consumption at continuous monitoring of <3.5mW and rapid stabilisation time of <2s. The combination of low power and fast stabilisation allows measurements to be made using as little as 10mJ per measurement.

*Smart*IR CO_2 Sensing – The Product Range

GSS manufactures a range of *Smart*IR CO_2 sensors designed for different applications. They all feature **low power** consumption and **fast response** times as detailed below.

GSS Product	**Typical Applications**	**Continuous Power Consumption**	**Response Time** (Configurable via filter type, flow rate, and casing options)	**Warm Up Time**	**Additional Temperature and Relative Humidity Integration**
COZIR Ambient	Building Control, IAQ, Horticulture	3.5 mW	30 secs to 3 mins	< 10 seconds	Sensirion SHT21 Sensor Integrated
COZIR Wide Range	Industrial safety, Diving, Automotive	3.5 mW	4 secs to 2 mins	< 10 seconds	Sensirion SHT21 Sensor Integrated
SprintIR	Metabolic assessment, Food packaging, Sports Science	35 mW	< 0.1secs using flow adaptor.	< 1 minute	N/A
MISIR	Building Control, IAQ, Horticulture	20 mW	2 mins	< 20 seconds	N/A
MinIR	Industrial safety, Diving, Automotive	3.5mW	10 secs to 3 mins	< 10 seconds	N/A

GSS *Smart*IR CO_2 sensor product range



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*Smart*IR CO_2 sensing – GSS Engineering Solutions

GSS has developed a range of CO_2 sensors to meet the wide range of conditions our customers need to measure. The range includes sensors optimised for high speed, or for low power, for high concentrations and for in line measurement. GSS can recommend the best sensor for particular applications and provide advice on how best to integrate these sensors into user products or processes.

When something special is required, GSS has significant experience in designing bespoke carbon dioxide measurement solutions for clients. We recognise that our clients are experts in their field, but may have less experience in sensor systems design and integration. GSS can design custom sensors, provide application support and expertise, or create and manufacture an entire user application.

Our team of engineers have developed unique solutions for our clients and can offer support in software, firmware, optical design, electronic design and mechanical design.

GSS *Smart*IR CO_2 Sensing – About Us

Gas Sensing Solutions, located in Cumbernauld, Scotland, was co-founded in 2006 by Managing Director Alan Henderson with investment provided by Tweed Renaissance Investment Capital and The Scottish Co-Investment Fund. Professor Des Gibson holds the role of Executive Chairman and Calum MacGregor is Operations and Technical Director.

Trading began in 2008 with an initial focus on the safety, spillage, flue gas analysers, internal air quality (IAQ) and heating ventilation and air conditioning (HVAC) sectors.

In 2010, GSS Launched COZIR, the World's Lowest Power Consumption NDIR CO_2 Sensor and in 2012 introduced SprintIR, the World's Fastest Response NDIR CO_2 Sensor.

GSS received a **John Logie Baird Award** in recognition of outstanding achievement in the 'Impact Through Innovation' category and won the **Shell Springboard Award** for Scotland, Northern Ireland & Northern England recognizing innovation in tackling climate change. In 2014, GSS won the **Institute of Physics Innovation award** for their low power CO_2 sensor technology.

IOP INNOVATION AWARDS WINNER 2014
IOP Institute of Physics

Shell Springboard
Regional Winner

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