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# GAS DETECTION SENSORS USING MEMS-A REVIEW

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**ABSTRACT**

A gas detector is a device that detects the presence of gases in an area, often as part of a safety system. This type of equipment is used to detect a gas leak or other emissions and can interface with a control system so a process can be automatically shut down. A gas detector can sound an alarm to operators in the area where the leak is occurring, giving them the opportunity to leave. This type of device is important because there are many gases that can be harmful to organic life, such as humans or animals. Gas detectors can be used to detect combustible, flammable and toxic gases, and oxygen depletion. Gas leak detection is the process of identifying potentially hazardous gas leaks by sensors. These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected. Exposure to toxic gases can also occur in operations such as painting, fumigation, fuel filling, construction, excavation of contaminated soils, landfill operations, entering confined spaces, etc.



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## INTRODUCTION

Gas leak detection methods became a concern after the effects of harmful gases on human health were discovered. Before modern electronic sensors, early detection methods relied on less precise detectors. Through the 19th and early 20th centuries, coal miners would bring canaries down to the tunnels with them as an early detection system against life-threatening gases such as carbon dioxide, carbon monoxide and methane. The canary, normally a very songful bird, would stop singing and eventually die if not removed from these gases, signaling the miners to exit the mine quickly. Before the development of electronic household carbon monoxide detectors in the 1980s and 1990s, carbon monoxide presence was detected with a chemically infused paper that turned brown when exposed to the gas. Since then, many electronic technologies and devices have been developed to detect, monitor, and alert the leak of a wide array of gases. As the cost and performance of electronic gas sensors improved, they have been incorporated into a wider range of systems. Their use in automobiles was initially for engine emissions control, but now gas sensors may also be used to insure passenger comfort and safety. Carbon dioxide sensors are being installed into buildings as part of demand-controlled ventilation systems. Sophisticated gas sensor systems are being researched for use in medical diagnostic, monitoring, and treatment systems, well beyond their initial use in operating rooms. Gas monitors and alarms for carbon monoxide and other harmful gases are increasingly available for office and domestic use, and are becoming legally required in some jurisdictions. Originally, detectors were produced to detect a single gas. Modern units may detect several toxic or combustible gases, or even a combination. (Dorman *et al.*, 2010) Newer gas analyzers can break up the component signals from a complex aroma to identify several gases simultaneously.

### GAS DETECTORS

Gas detectors can be classified according to the operation mechanism (semiconductors, oxidation, catalytic, photoionization, infrared, etc.). Gas detectors come packaged into two main form factors: portable devices and fixed gas detectors. Portable detectors are used to monitor the atmosphere around personnel and are either hand-held or worn on clothing or on a belt/harness. These gas detectors are usually battery operated. They transmit warnings via audible and visible signals, such as alarms and flashing lights, when dangerous levels of gas vapors are detected. Fixed type gas detectors may be used for detection of one or more gas types. Fixed type detectors are generally mounted near the process area of a plant or control room, or an area to be protected, such as a residential bedroom. Generally, industrial sensors are installed on fixed type mild steel structures and a cable connects the detectors to a SCADA system for continuous monitoring. A tripping interlock can be activated for an emergency situation.

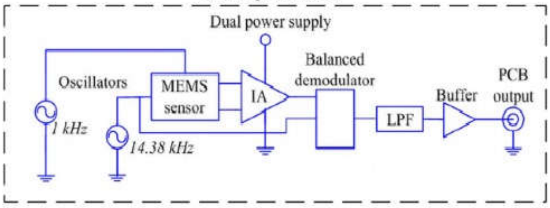


**Figure 1. Block diagram of the signal conditioning system of the MEMS magnetic field sensor**

Fabrication and Characterization of a Suspended TCD Integrated With a Gas Separation Column. Shree Narayanan and Masoud Agah, Senior Member, IEEE In this paper they report the design, fabrication, and evaluation of performance of a glass on unique high aspect ratio resistor and employed in a micro thermal conductivity detector (µTCD). Signi cant improvements in power dissipation and warm-up time by suspending the resistors in the microchannels were demonstrated by finite-element simulations. Dry release of 170µm-diameter coil-shaped resistors on Boro oat enabled by Microfabrication techniques in a two-mask process. They independently processed the micro uidic channels on silicon wafers. They use deep reactive ion etching and subsequently anodic bonded to the glass substrate harboring the TCD resistors.

And they concluded that by presenting a unique technique to fabricate resistor coils, as170 µm tall as, on glass and they employed it in a TCD. Advantages:1. Similar to bulk-etched metal lms it offered high thermal isolation. 2. They have been robust to liquid and gas ow, despite minimal anchoring. 3. The silicon can be processed independently and exibility, because the processing on glass did not render it un t for anodic bonding. when compared to nonsuspended resistors the resistors have been characterized by an order of magnitude reduced power consumption (13mW) and warm-up time (sub-6ms).

Robust MEMS Gyroscope Based on Thermal Principles by Jamal Bahari, Rui Feng, and Albert M. Leung, Member, IEEE. They designed, fabricated, and characterized two variants of a novel single-axis thermal gyroscope without seismic mass .The differential temperature detection due to the Coriolis Effect is the operating principle of the device by which an oscillatory gas stream has been created by alternating two resistive microheaters. The bulk micromachining technology used by this fabrication process, by which silicon substrate using platinum as the only conductor layer in this process. The device structure has two resistive temperature detectors that have been equally spaced from the two microheaters. With minimal structural support the 170-nm-thick platinum detector and heater microstructures has been freely suspended over a cavity that has been etched into the substrate. They construct a computer-controlled precision rotary stage for measuring the device performance accurately. They demonstrate excellent linearity within the tested ±3.5 revolution per second angular rate of rotation of the device and show sensitivities of 0.947 and 1.287mV/°/s at 20 mW heater powers. The drop shock of 2,722 to 16,398g (9.81 m/s2) validates the robustness of the device.

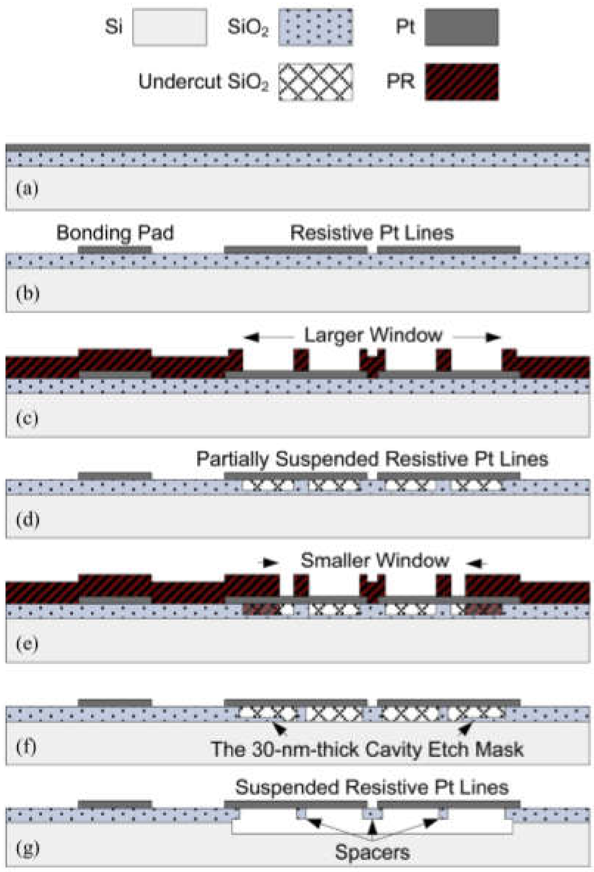


**Fig. 2. Fabrication process of the thermal gyroscope with low thermal mass**

They concluded that the MEMS thermal gyroscope that the Coriolis acceleration deflects the path of bidirectional gas flow created by using two micro heaters and demonstrated that this angular rate sensing principle by two design variants producing very linear responses to that of the applied rotations. The unwanted linear acceleration signals can be cancelled using this device and due to the less-than-perfect rotational symmetry, rudimentary devices shows observable acceleration responses in the sensor cavity. The fabricated prototypes withstand shock accelerations of several thousands of g because of the simple device structure and the absence of a vibrating solid proof mass. The unmatched robustness of the thermal gyroscope is achieved at the costs of sensitivity and frequency response compared to the MEMS state of the art vibrating mass gyroscope.

Sensor for Thermal Gas Analysis Based on Micromachined Silicon-Microwires by Kurt Kliche, Gerhard Kattinger, Sophie Billat, Liwei Shen, Stephan Messner, and Roland Zengerle For the thermal detection, they present a microelectro mechanical systems-based sensor of changes of gas mixtures such as the CO2 concentration in air with low power consumption (<10 mW) and high long term stability through the absence of moving or consumptive components are the properties of this sensor. They analysed the gas mixture surrounds the sensor chip and that has three silicon-microwires (thermistors). Sinusoidal heating power is supplied to the centred wire (heater). From the heater, located in different distances this induces a thermal response via the surrounding gas to measurement wires (detectors). They analysed the phase shift between heating power and induced thermal responses at the detectors and they depends on the thermal properties of the gas. After calibration, within a mixture of different, the sensor is able to quantify the concentration of an individual component but known gas components. They demonstrated by measuring the CO2 concentration in N2/CO2 mixtures with 0.2% resolution at constant temperature and pressure.

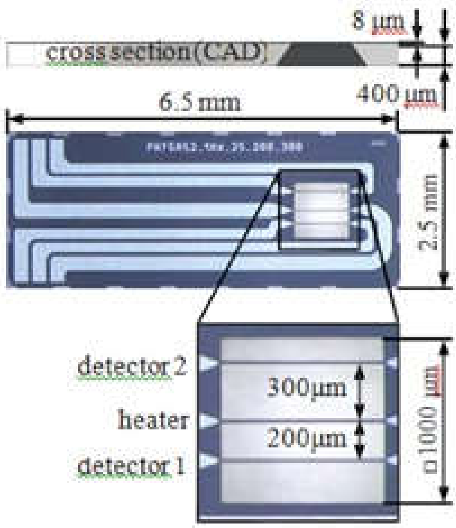


**Fig. 3. Cross-sectional view of measurement setup**

They concluded that by presenting a sensor for analysing thermal gas and that can be used to distinguish mixtures of gases of well-known components. The sensor works self-suf cient and is powered via an USB interface connected to a PC in the current state. They utilize simple analog electronic components to generate sinusoidal heating power and the phase shifts between two detector signals in two different distances are determined from the heater (200 µm and 300 µm). They used mean values of 12000 periods taken within 1 min the presented sensor in this rst stage of development and that can be calibrated to measure CO2 concentrations in a mixture of dry CO2 and N2 gas already with 0.2% lower limit of detection and 0.13% resolution. The sensor to pressure and temperature due to the cross sensitivity they requires to measure the pressure and the temperature with a resolution signi cantly better than 1 mbar and 0.04 °C respectively.

PRT Embedded Microheaters for Optimum Temperature Distribution of Air-Suspended Structures for Gas Sensor Applications by Golla Keshavaditya, Golla Raviteja Eranna, and Golla Eranna. A lot of research effort based on metal oxides has been directed toward the development of small dimensional gas sensing devices, ranging from toxic gas detection to pollution monitoring in the air ambience for practical applications. The demand has been increased for better environmental control and safety research activities for development of microgas sensors. MEMS-based sensors in the form of thin or thick films seem to be more promising for this purpose. Based on the principle of electrical conduction variation the Metal oxide-based sensors works and for the sensing films for best sensitivity values with crucial predetermined temperature. These sensors have the importance of Creating correct temperature and the proper temperature distribution. And it is crucial for creating thin film platforms for and practically limits the yield. Using ANSYS, the results obtained for thick air-suspended platform, for a PRT (platinum resistance thermometer) embedded microheater and that is suitable to operate by a dc battery source. Both PRT and the microheater were defined in a single photolithography step and realized on an oxidized silicon substrates (SiO2/Si). To simulate the data, they use realistic values and to obtain the optimum temperature distribution, 400 °C and air-suspended platform has the area of 5 mm × 4 mm. These studies help in understanding the heat distribution on the membrane and to help greatly to visualize the microheater design, where the sensing layer placed and gets the optimum sensing properties of microgas sensors. It is easy to confirm and control the required temperature necessary for the sensing layer using embedded PRT.

Integrated Separation Columns and Fabry-Perot Sensors for Microgas Chromatography Systems by Karthik Reddy, Jing Liu, Maung Kyaw Khaing Oo, and Xudong Fan. A monolithic subsystem that integrated a microgas chromatography (µGC) separation column and on column, nondestructive Fabry-Perot (FP) vapor sensors on a single silicon chip was developed by them. The device has been fabricated to create fluidic channels and polymers that has been deposited on the same silicon chip to act as a stationary phase or an FP sensor, thus avoiding dead volumes caused by the interconnects between the column and sensor traditionally and used in µGC. Two integration designs are A 25-cm long µGC column that served as the stationary phase and the FP sensor was coated with a layer of polymer and has the greatest level of integration and capable of sub-second response times and has less than 10 ng detection limits. 2. An FP sensor array with a 30-cm long µGC column spray coated with different vapor sensing polymers was integrated, which improves the system detection sensitivity and flexibility. The FP sensors have a detection limit of tens of picograms or∼500 ppb with a sub-second response time. Furthermore, the FP sensor array responds to a mixture of analytes separated by the integrated separation channel. They have concluded by fabricated and characterized two subsystems, µGC column and FP sensor (array) integration design, which are reproducible, robust, and fast in response and can potentially, improve the efficiency and reduce the size of µGC systems. The second design they used a sensor array that demonstrated the ability to separate multiple analytes and gather information from multiple sensors simultaneously to conduct pattern analysis for qualitative and quantitative detection of VOC mixtures.

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