



A conversation on gas sensors

1 Sensors are an extension of the human perception of the world

Human beings are equipped with five primary senses: sight, hearing, smell, taste, and touch. These senses, along with various perceptual systems, enable us to navigate and understand the world around us. However, as science and technology have advanced, humans have taken this further by developing machines that can "perceive" the world—thanks to sensor technology.

Sensors are devices designed to detect changes or events in the environment. They convert this information into electronic signals, which can then be processed by computers for analysis or decision-making. Today, sensor technology plays a crucial role across numerous industries, including manufacturing, aerospace, automotive, healthcare, robotics, and even in everyday life.

As sensor technology continues to evolve, it holds the potential to bring humanity closer to a future powered by smarter, more connected systems, enhancing our capabilities and improving our quality of life.

2 Gas sensors

In addition to well-known sensors like temperature, humidity, and pressure sensors, gas sensors play a crucial role in various applications. While semiconductor sensing technology began to spread to Japan in the 1950s, it was Naoyoshi Taguchi, the founder of Figaro, who revolutionized the field by inventing the first semiconductor gas sensor in May 1968. This breakthrough allowed for the detection of low concentrations of flammable and reducing gases using a simple circuit.

The semiconductor gas sensor, named TGS (Taguchi Gas Sensor), became a game-changer. It was widely incorporated into gas leakage alarms, making it possible to detect hazardous gases such as liquefied petroleum gas (LPG) in homes and factories. This innovation not only gained popularity in Japan but also spread internationally, pushing gas sensor technology to the forefront of safety systems and setting the stage for further advancements in the field.



On the other hand, Europeans began exploring catalytic and electrochemical sensors after identifying the limitations of semiconductor sensors. The theory of gas sensors was not introduced to China until the 1970s, and the country started developing gas sensors in the 1980s. During this time, the production technology was primarily derived from Germany.

3 Gas sensor classification

Gas sensors can be broadly categorized into several types based on their sensing mechanisms and applications. These include semiconductor sensors, electrochemical sensors, PID sensors, photochemical sensors, catalytic combustion sensors, and infrared sensors. Here's a closer look at each type:

1.Semiconductor Sensors

Semiconductor sensors are widely used due to their broad application range and affordability. They are commonly employed in household gas detection and various other fields, making them the most widely used type of gas sensor today.

2.Electrochemical Sensors

Electrochemical sensors are ideal for detecting low-concentration toxic gases as well as non-toxic gases like alcohol. They are primarily used in industrial applications and road traffic safety monitoring.

3.Catalytic Combustion Sensors

These sensors are best suited for detecting combustible gases and are commonly used in industrial settings where safety is a priority.

1.Infrared Sensors

Infrared sensors are effective for detecting gases like methane and carbon dioxide. They are widely used in air quality monitoring, industrial processes, safety protection, and production process monitoring.

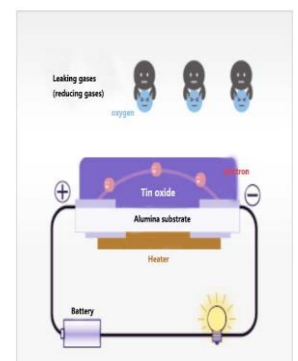
2.PID Sensors (Photoionization Detectors)

PID sensors are highly sensitive and are primarily used to detect volatile organic compounds (VOCs) at very low concentrations, making them valuable for environmental monitoring and industrial applications.

Semiconductor gas sensors

Semiconductor gas sensors are among the most common and practical types of gas sensors used today. They can be classified into resistive and non-resistive types based on their gas sensing mechanisms. These sensors detect changes in the operating current or voltage, which vary depending on the gas concentration, and are primarily used to detect flammable gases such as hydrogen and natural gas.

In clean air, oxygen molecules adsorb onto the surface of tin oxide, binding the electrons and making it difficult for the electrons to flow. However, in the presence of a leaking gas (typically a reducing gas), the oxygen on the surface reacts with the reducing gas, causing it to disappear. This reaction frees up the electrons in the tin oxide, allowing them to flow more easily, which in turn alters the sensor's electrical properties.



Semiconductor gas sensors offer several advantages, including low cost, ease of manufacturing, high sensitivity, fast response times, long lifespan, low sensitivity to humidity, and simple circuitry. However, they also have some drawbacks: they require high operating temperatures, have poor selectivity for different odors or gases, exhibit variable component parameters, suffer from limited stability, and consume relatively high amounts of power.

Electrochemical gas sensors

Electrochemical gas sensors can be classified into four types: galvanic, controllable potential electrolytic, electric, and ion-electrode types. Ion-electrode gas sensors, one of the earliest types, detect gases by measuring ion-polarizing currents. These sensors consist of a detection electrode, a counter electrode, and an ionic conductor, often made from a noble metal catalyst. Many flammable, toxic, and harmful gases exhibit electrochemical activity and can undergo oxidation or reduction reactions. By utilizing these reactions, the gas composition can be identified and the concentration detected.

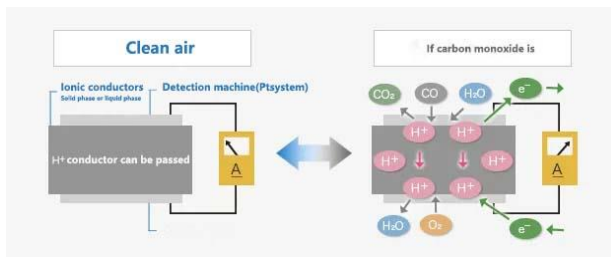


Image source: Figaro Technical Information

The main advantages of electrochemical gas sensors include their high sensitivity and excellent selectivity for detecting specific gases.

Scenarios for Electrochemical Gas Sensor Applications:

- ① Trace gas detection at industrial sites
- ② Environmental protection trace gas detection
- ③ Oxygen content detection on special occasions
- ④ Household toxic gas detection

Catalytic combustion gas sensors

The working principle of the catalytic combustion sensor involves the oxidation and combustion of gas-sensitive materials (e.g., Pt heating wires) under the influence of catalysts when electrified. The combustion heats the wires, causing a change in their resistance value, which allows the sensor to detect gas presence.

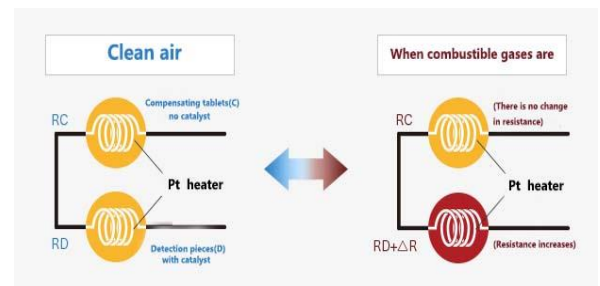


Image source: Figaro Technical Information

Catalytic combustion gas sensors are known for their accurate measurements, rapid response times, and long lifespan. The output of these sensors is directly correlated with the potential risk of environmental explosions, making them the leading sensor type in safety detection applications.

Disadvantages of Catalytic Combustion Sensors:

- ① Within the range of flammable gases, there is no selectivity.
- ② Concealed fire work, there is a risk of ignition and explosion.
- ③ Most of the elemental organic vapors have a toxic effect on the sensor.

Infrared gas sensor

Most gases exhibit characteristic absorption peaks in the mid-infrared region. The concentration of a specific gas can be determined by detecting absorption at these characteristic peaks. Infrared gas sensors operate based on the principle that target gases absorb infrared light at specific wavelengths, causing molecular vibrations. The amount of infrared light transmitted through the gas is inversely related to its concentration, allowing for precise gas detection.



Image source: Figaro Technical Information

Traditionally, infrared sensors are mostly analytical instruments, but in recent years, MEMS technology has been used as the basis for the development of the sensor industry, which has significantly reduced its size and has gradually been applied in the industrial field.

Infrared gas sensors can effectively distinguish the type of gas and accurately determine the gas concentration.

Infrared gas sensors consume less energy and the overall gas detector can run for longer. Even in oxygen-deficient environments, the infrared sensor detects accurately and does not cause "poisoning".

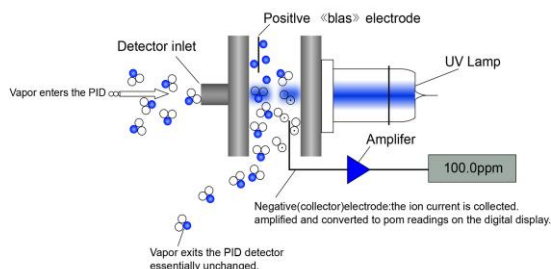
Scenarios for IR Gas Sensor Applications:

- ① Quantitative detection of combustible gas
- ② Household and industrial CO₂ detection
- ③ Quantitative detection of combustible gas, sulfide and nitrogen oxides in the field of industry and environmental protection

PID Gas sensors

The PID (Photoionization Detector) uses an ultraviolet light source to excite and ionize the measured gas, producing positive and negative ions. The current generated by these ionized particles is amplified by the detector, displaying the concentration of the gas in ppm.

These ions pass through the electrodes and quickly recombine to form the original organic molecules, without causing any damage to them. The PID does not "burn out" and does not require frequent replacement of standard gases, allowing the gas being tested to be collected for further analysis.



PID gas detectors are capable of detecting very low concentrations of volatile organic compounds (VOCs) and other toxic gases. Their sensitive detection of VOCs, in particular, makes them invaluable in emergency response situations.

Key Benefits of PID Gas Sensors:

1. Fast response and recovery, with a wide detection range.
2. Absolute zero point, allowing for quantification and high sensitivity.
3. Low energy consumption, low operating temperature, and intrinsic safety.

Main Application Areas of PID Gas Sensors:

1. Public transportation safety.
2. Firefighting and emergency rescue operations.
3. Production safety and pipeline leak monitoring in petrochemical industries.
4. Leak detection and pollution monitoring in environmental protection chemical parks.
5. Personal protection monitoring and home environment testing.



Contact us
info@htnova.com