

Gas Sensor Technologies

Los Alamos National Laboratory has developed a portfolio of advanced solid-state gas sensor technologies that increase the life, reliability, and accuracy of many gas sensors on the market today. Gas sensors are important components of detector /analyzer systems and any changes in their size, performance, and power consumption directly translate to the performance and sales of the instruments in which they are utilized. The global market for gas sensors and gas metering equipment including secondary instrumentation was estimated at \$2.8 billion in 2004 and rose at an average annual growth rate of 5.9% to \$3.8 billion in 2009. Sensors and monitors represent the largest and second highest growing segment, rising at an average annual growth rate of 6.3% from \$1.3 billion in 2004 to nearly \$1.8 billion in 2009.

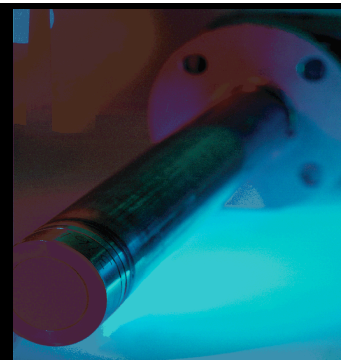
Available Products	O ₂	NO _x	CO	H ₂	Hydro-carbons	Ammonia (NH ₃)
Patented Sulfur-Resistant Electrode	●					
Carbon Monoxide Sensor with Carbon Filter			●			
NO _x / Ammonia Sensor		●				●
Hydro-Carbon / Total Combustibles Sensor			●	●	●	

Available Methods for Manufacturing Sensors	NO _x	CO	H ₂	Hydro-carbons	Ammonia (NH ₃)
Tape Casting	●	●	●	●	●
Thin Film Deposition	●	●	●	●	●

See brochures for details and licensing options

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Sulfur Resistant Electrodes for Zirconia Oxygen Sensors

Summary:

Scientists at Los Alamos National Laboratory have developed a ground-breaking, high temperature, sulfur resistant electrode for oxygen (O₂) sensors that increases their life, stability, and accuracy. This patented electrode, Terbium-Yttrium-zirconium oxide (Tb-YSZ), is resistant to sulfur and other acidic compounds present in exhaust gases that destroy O₂ sensors on the market today.

Field Testing:

A zirconia O₂ sensor with a Tb-YSZ electrode was tested in a high sulfur coal fired power plant side by side with a normal zirconia O₂ sensor. The results of the test showed that the O₂ sensor manufactured with a Tb-YSZ electrode held up **forty times longer** before failure than the normal zirconia O₂ sensor with platinum electrodes.

Applications:

Any combustion process in which O₂ levels are monitored and acidic compounds like sulfur are present. Oxygen sensors for automobiles is of particular importance, with sales in China rising by over 20% year over year:

- Power plants
- Refineries
- Co-generation plants
- Automobiles
- Incinerators

Patent Status:

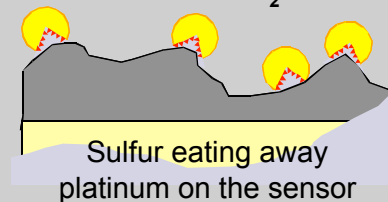
U.S. Patent 5,543,025, U.S. Patent 5,695,624, and U.S. Patent 6,277,256

Licensing Status:

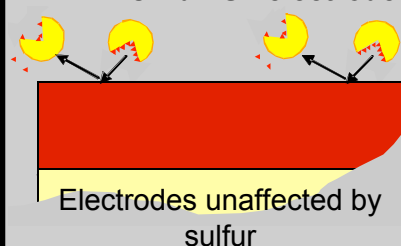
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Current technologies available for detecting oxygen in high sulfur, flue gas applications	Life in a high sulfur environment	Accuracy	Reliability	Response time
Zirconia oxygen sensors with a Tb - YSZ electrode	●	●	●	●
Zirconia oxygen sensors (Platinum electrodes)	●	◐	◐	●
Paramagnetic oxygen transmitter (Samples gas from stack, and analyses externally)	○	○	◐	●
Optical sensor (Diode laser and detector)	◐	●	●	●

Current zirconia O₂ sensors



Zirconia O₂ sensors with LANL's Tb-YSZ electrode



Benefits

- Increases zirconia O₂ sensors:
 - Lifetime
 - Reliability
 - Accuracy
- Cost effective
- Tb-YSZ can be applied as a coating to almost all zirconia O₂ sensors

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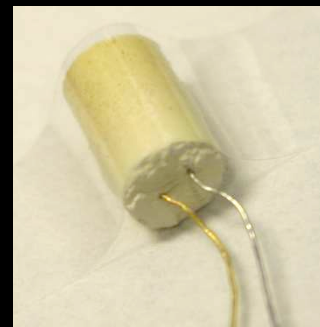
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LALP-06-114



Carbon Monoxide Sensor

Summary:

Scientists at Los Alamos National Laboratory (LANL) have developed an electrochemical carbon monoxide (CO) sensor that is more reliable and reproducible than any other CO sensor on the market today. The patented method for producing the sensor ensures reproducibility and reduces the need for calibration of every sensor coming off the production line.

Market Need:

Inaccurate CO sensors on the market today result in alarms failing to go off, or alarms going off when CO is not present. Both can result in substantial costs to a company. In the US and to a lesser extent abroad, there is an additional incentive for CO sensor deployment for domestic and vehicular detection, possibly allied with fire detection. In addition, there is increasing U.S. state legislation requiring CO detector deployment in residential and other occupied buildings, plus movement by advocacy groups that may make this a mandatory safety measure in buildings and automobiles. LANL's CO sensor offers a solution to this market need by providing a reliable CO sensor.

Applications:

Any application that requires CO measurement:

- Homes and apartments
- Manufacturing plants
- Offices
- Automobiles
- Hospitals

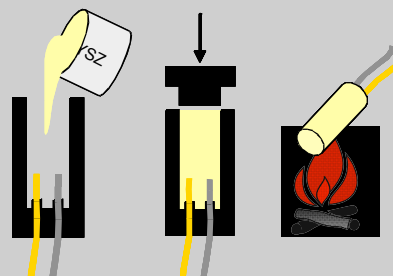
Patent Status:

U.S. Patent 6,605,202 and one pending patent

Licensing Status:

Available for exclusive, non-exclusive, and field of use licensing

Production Method



The stability and reproducibility of the sensor is achieved by using wire electrodes instead of the usual thin or thick film electrodes that are currently employed.


Benefits

- Increases CO sensors
 - Lifetime
 - Reliability
 - Accuracy
 - Stability
 - Reproducibility
- Cost effective
- Easy to manufacture
 - Tape Casting method can be used
- Low rejection rate
- Low humidity dependence

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Current technologies available for detecting carbon monoxide	Expense	Accuracy	Life	Power usage	Overall reliability
LANL's electrochemical					
Electrochemical (amperometric)					
Biomimetic (colorometric)					
Semiconducting (MOS)					

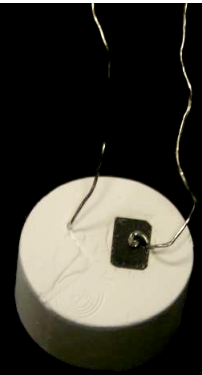
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Hydrocarbon / Total Combustibles Sensor



Summary:

Scientists at Los Alamos National Laboratory (LANL) have developed an electrochemical hydrocarbon sensor that is more reliable and reproducible than any other hydrocarbon sensor on the market today. The patented method for producing the sensor ensures reproducibility and reduces the need for calibration of every sensor coming off the production line.

Market Need:

Liquefied petroleum gas (LPF) is transported around the world and stored every day. A small leak in a unit containing LPF can result in an explosion killing and destroying everything in its vicinity. Operators must protect the environment from negative effects of oil & gas production. A leakage can be disastrous for the environment and extremely costly for the operator. The Hydrocarbon Leak Detector will limit the environmental impact and cost of an incident by enabling fast and efficient implementation of corrective measures. LANL's sensors will also help operators comply with current and future environmental requirements. Current sensors are either unreliable or highly inaccurate. LANL's CO sensor is both accurate and reliable offering increased safety to those transporting and storing LPF and other hydrocarbons.

Applications:

Wherever hydrocarbons in the air need to be monitored:

- Monitoring for leaks in tanks containing bottled gas (like propane)
- Warehouses
- Ships and tanker trucks transporting LPF
- Refineries

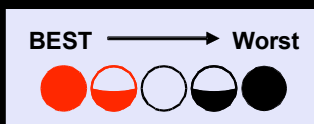
Patent Status:

U.S. Patent 6,605,336 and one pending patent

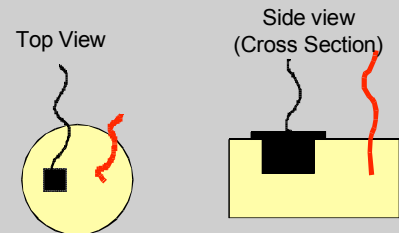
Licensing Status:

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Current technologies available for detecting hydrocarbons	Expense	Accuracy	Life	Overall reliability
LANL's electrochemical	●	◐	●	●
Catalytic bead	●	●	●	◐
Semiconducting (MOS)	◐	●	◐	◐



Production Method



Similar to the carbon monoxide sensor, but the electrodes are made of a platinum wire and a special oxide pellet.

Benefits

- Increases hydrocarbon sensors:
 - Lifetime
 - Reliability
 - Accuracy
 - Stability
 - Reproducibility
- Cost effective
- Easy to manufacture
 - Tape casting method can be used
- Low rejection rate

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NO_x / Ammonia Sensor

Summary:

Scientists at Los Alamos National Laboratory (LANL) have developed an electrochemical NO_x / ammonia sensor that is more reliable and reproducible than any other NO_x / ammonia sensor on the market today. The patented method for producing the sensor ensures reproducibility and reduces the need to calibrate every sensor coming off the production line.

Market Need:

The EPA is enforcing more stringent emissions standards on the automobile industry and the power industry. In particular, NO_x and ammonia are two pollutants that the EPA is mandating automobile manufacturers and power plants to monitor. By 2030, the EPA estimates the annual reduction of NO_x emissions by 800,000 tons. The state implementation plans and directives on emission requirements have stimulated the growth of a \$1.5 billion exhaust sensors market. However, current NO_x and ammonia sensors on the market today are expensive and unreliable. LANL's NO_x / ammonia sensor is both reliable and cheap to manufacture.

Applications:

Any application that requires monitoring of NO and ammonia:

- Automobiles (diesel engines)
- Generators
- Heavy equipment
- Power plants
- Refineries

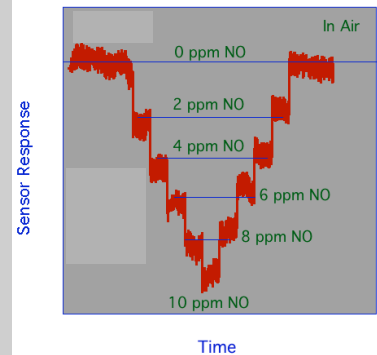
Patent Status:

Patent pending

Licensing Status:

Available for exclusive, non-exclusive, and field-of-use licensing

Proven Test Results



Benefits

- Increases NO_x / ammonia sensors:
 - Lifetime
 - Reliability
 - Accuracy
 - Stability
 - Reproducibility
- Cost effective
- Easy to manufacture
 - Similar to CO sensor
 - Tape casting method can be used
- Low rejection rate

Current technologies available for detecting NO _x and ammonia	Expense	Accuracy	Life	Overall reliability
LANL's electrochemical				
Electrochemical amperometric				

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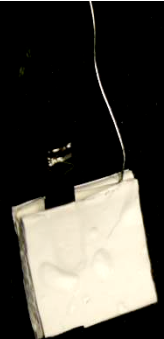
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LALP-06-111



Tape Casting Method for Sensor Manufacturing

Summary:

Scientists at Los Alamos National Laboratory (LANL) have developed an innovative method for gas sensor manufacturing using tape casting.

Market Need:

Current methods of making mixed potential sensors are not readily adaptable to large-scale production. In addition, the sensors produced by these methods lack the stability, reproducibility, and selectivity that are needed to make them suitable for widespread use. Therefore, a simplified method of making mixed potential sensors is needed., in addition to a method of making sensors having improved thermal stability, reproducibility, and selectivity. LANL's tape cast sensor technology meets these and other needs by providing a method of making mixed potential sensors in which electrolyte material is cast into a tape. Prefabricated electrodes are then partially embedded between two wet layers of the tape to form a green sensor, and the green sensor is then heated to sinter the electrolyte around the electrodes. The resulting sensors can be used in applications such as, but not limited to, combustion control, environmental monitoring, and explosive detection

Applications:

Gas sensor manufacturing:

- Carbon monoxide
- Hydrocarbon
- NO_x / Ammonia
- Any gas sensor with two electrodes and an electrolyte

Patent Status:

Patent pending

Licensing Status:

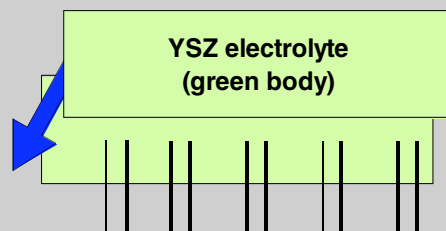
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Benefits

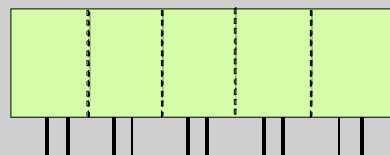
- Decreases production time
- Increases quality
- Decreases cost
- Simplifies the manufacturing process
- Allows application of thin-film deposition

Production Method

- 1 Place electrodes between two layers of tape made out of YSZ electrolyte



- 2 Cut the strip into individual sensors and dry



- 3 Cure the sensors



Contact:

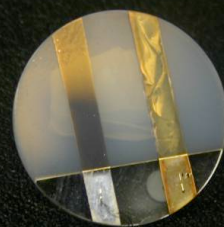
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LALP-06-116



Thin Film Deposition Method for Sensor Manufacturing

Summary:

Scientists at Los Alamos National Laboratory (LANL) have developed an innovative method for gas sensor manufacturing using a thin film deposition. The thin film requires very little material and can be applied in high throughput applications.

Market Need:

The gas sensor market is highly competitive. LANL's thin film deposition method for manufacturing gas sensors decreases manufacturing time and costs, while increasing consistency and quality. With the use of thin film deposition, gas sensor manufacturers can offer a higher quality product at a very competitive price.

Applications:

Gas sensor manufacturing:

- Carbon monoxide
- Hydrocarbon
- NO_x / ammonia
- Any gas sensor with two electrodes and an electrolyte

Patent Status:

Patent pending

Licensing Status:

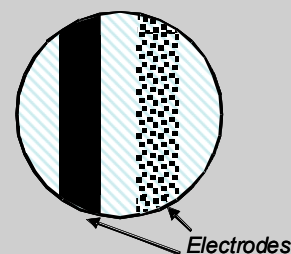
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Benefits

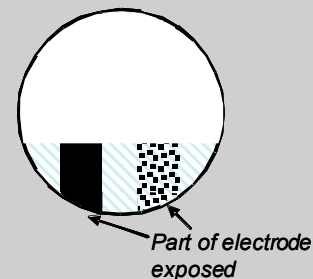
- Decreases production time
- Increases quality
- Decreases costs
- Simplifies the manufacturing process
- Allows application of tape casting method

Production Method

- 1 Place thin electrodes on surface (inert substrate)



- 2 Spray on a thin film of electrolyte over part of the sensor



- 3 Cure the sensors



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LALP-06-117