Argonne NATIONAL LABORATORY

Office of Technology Transfer

Hydrogen Sensor

Fast, Sensitive, Reliable, and Inexpensive to Produce

2006 R&D 100 Award Winner

FEATURES AND BENEFITS

Argonne's hydrogen sensor outperforms competing technologies.

Speed

- Requires no warm-up and responds in less than 75 milliseconds in a 2% hydrogen atmosphere. Competing sensors typically take one second to tens of seconds.

Sensitivity

- Detects hydrogen concentrations as low as 0.0025% (25 parts per million) without elaborate signal amplification.

- Minor leaks can be found before concentration levels require full system shutdown.

Selectivity

- Detects H_2 reproducibly, even in the presence of oxygen, water vapor, and other gases.

Low Power Use

- Unlike other sensors, requires no heaters or other supplementary power as some existing sensors do.

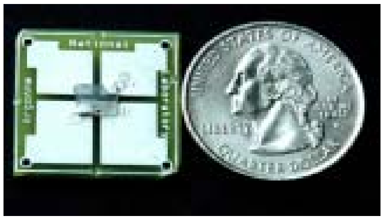
Simple, Inexpensive Fabrication

- Construction is based on scalable processes routinely used to make electronic components, resulting in minimizing the ultimate cost. Only $50 worth of palladium is needed for approximately 16,000 sensors.

Background

Hydrogen is a promising potential fuel for cars, buses, and other vehicles and can be converted into electricity in fuel cells. It also is already used in medicine and space exploration as well as in the production of industrial chemicals and food products.

Safety is an important issue when using hydrogen. An explosive mixture can form if hydrogen leaks into the air from a tank or valve, posing a hazard to drivers, equipment operators, or others nearby.



Commercially available sensors can detect the presence of hydrogen and then close valves, shut down equipment, or trigger alarms. However, current technologies typically have limitations related to cost, speed of operation, susceptibility to interference from other gases, and temperature range.

Building a Better Sensor

Researchers at Argonne National Laboratory have created a tiny sensor – the world's fastest – that reliably overcomes the limitations associated with current hydrogen sensor designs.

The key to its unique performance is what Argonne researchers call its nanostructured, self-assembled thin-film construction. First, a one-molecule-thick layer of siloxane is applied to a glass substrate. The "sticky foot" of the siloxane molecule binds it strongly to the glass while the rest of the long-chain molecule remains slippery. Onto this slippery layer researchers evaporate an extremely thin blanket of tiny (2 to 10 nanometer) palladium beads.

Palladium particles are chosen because, when exposed to hydrogen, they adsorb the gas and swell slightly to form palladium hydride. In fact, some available "thick film" sensors rely on the different conductivity of palladium and palladium hydride to indicate hydrogen concentration.

In contrast, the Argonne design employs an ultra-thin layer of palladium beads that allows both faster hydrogen adsorption and greater sensitivity due to the mobility of the palladium hydride beads. As the enlarged beads move into contact with each other, they create pathways for electrical current. When hydrogen concentration drops, the particles shrink quickly and revert to palladium. Electrical conductivity also drops.

Satisfies stringent DOE requirements

- Meets or beats all six response-time and concentration criteria set by the U.S. Dept. of Energy (DOE) for hydrogen sensors to be used in vehicle, process plant, or pipeline applications or as personnel monitors.
- No other existing sensor meets all of these criteria.

POTENTIAL APPLICATIONS

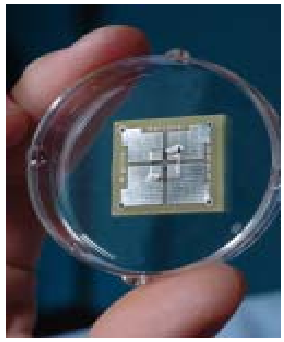
- Auto safety installation.
- Stationary fuel cell installations
- Nuclear reactors
- Ammonia and methanol production
- Petroleum refining
- Hydrogenation of edible oils
- Battery charging
- Medical diagnostics
- Space shuttle and space station systems
- Mine safety and ore reduction operations

ABOUT ARGONNE TECHNOLOGY TRANSFER

Argonne National Laboratory is committed to developing and transferring new technologies that meet industry's goals of improving energy efficiency, reducing wastes and pollution, lowering production costs, and improving productivity. Argonne's industrial research program, comprised of leading-edge materials research, cost-saving modeling, and unique testing and analysis facilities, is providing solutions to the challenges that face U.S. manufacturing and processing industries.

First Application: Transportation

Argonne has exclusive licensing agreements for all applications of the new sensor with Makel Engineering, Inc. (Chico, CA). Argonne and Makel expect that the innovative hydrogen sensor will first find application in the transportation sector.



Team members have developed the world's fastest commercially producible hydrogen sensor based on controlling the way nanometer-sized palladium particles self-assemble onto an insulating surface.

Hydrogen can be burned directly in an engine or electrochemically combined with oxygen in an onboard fuel cell with electric output powering the wheels and other vehicle systems.

The sensor helps to ensure the safe and proper operation of subsystems aboard a vehicle, in component fabrication areas, and in facilities for vehicle repair or fueling.

Several major automakers are conducting research on hydrogen-powered and fuel cell vehicles, including BMW, Ford Motor Co., DaimlerChrysler, General Motors, Honda, Toyota, and Volkswagen.

Others are also funding fuel cell vehicle research. The U.S. DOE launched the FreedomCAR Initiative in 2002 and the Hydrogen Fuel Initiative in 2003, proposing $1.7 billion to support development of fuel cell technology (mobile and stationary) in partnership with the private sector.

Fifteen other nations, along with the U.S. and the European Union, also are members of the International Partnership for the Hydrogen Economy (www.iphe.net), established in 2003 to accelerate the development of hydrogen and fuel cell technologies.

DOE's Office of Hydrogen, Fuel Cells and Infrastructure Technologies has evaluated possible government support options to aid market development. Depending on the year of commercial introduction (2012 or 2015) and the level of support provided, the number of hydrogen fuel cell vehicles in use in the United States could range from 1.8 million to 10 million vehicles by 2025.

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