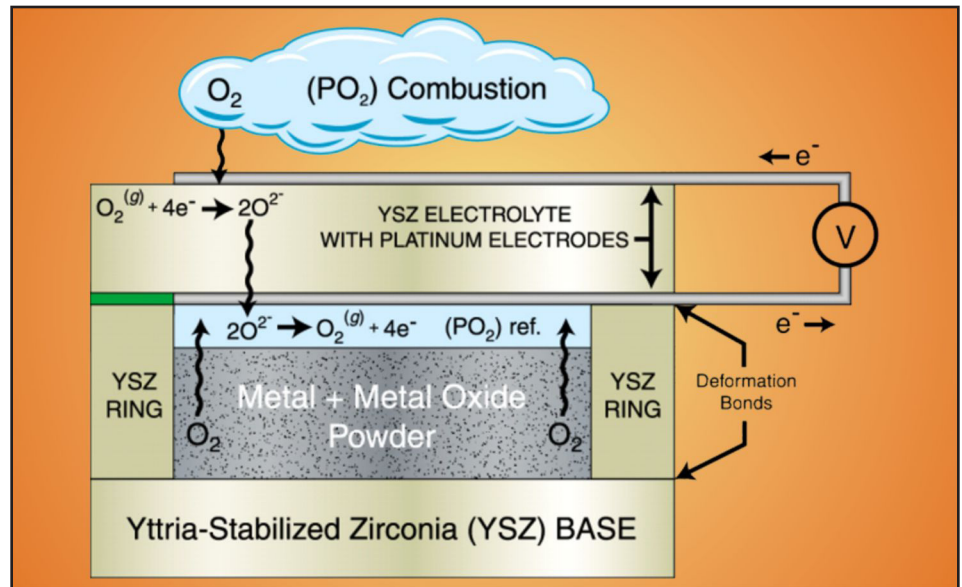


Low-Cost, High-Temperature Sensor Enables In-Chamber Oxygen Measurements

Background

Coal-fired power generation, glass processing, petrochemical manufacturing, and the internal combustion engine all involve combustive processes. In each of these, the monitoring of various substances is necessary to help improve combustion efficiency, keep emissions in check, decrease excess air, reduce energy losses, and prevent corrosion. Oxygen is one of these substances. In internal combustion engines, it is important to monitor oxygen to maintain the proper air-fuel ratio in the interest of optimizing engine efficiency and maintaining the desired emissions profile. Oxygen sensing has always taken place external to the combustion chamber, for two main reasons. First, prior methods of sensing oxygen from inside combustion chambers were costly and bulky. Second, no device was available to withstand temperatures inside the chamber (up to 1600°C). With support from the U.S. Department of Energy, Argonne National Laboratory (ANL) and Ohio State University (OSU) developed the world's first high-temperature oxygen sensor that can be used inside combustion chambers.



The world's first low-cost, compact high-temperature oxygen sensor that requires no external reference air supply

The Technology

This sensor is enabled by an internal reference air chamber sealed by a unique deformation bonding method that joins the protective ceramic housing components together without using intermediate bonding materials that typically alter the ceramic's oxygen conductivity or result in air leaks. The deformation bonding method produces a rugged, longer-lasting device capable of withstanding higher temperatures. These high-temperature capabilities facilitate placing the sensor (or multiple sensors) close to the source of combustion to enable

faster and more accurate monitoring and feedback. This also provides the opportunity to map the entire combustion zone. Eliminating the need for external reference air and joining ceramic components without intermediate bonding materials permits the production of a very compact (millimeter-sized) oxygen sensor, having excellent oxygen conductivity through the housing, at an extremely low production cost (less than \$200), with superb stability, low drift, and high sensitivity to changes in oxygen levels.¹

The ability to use multiple oxygen sensors, due to their lower cost and



smaller package size, in closer proximity to combustion sources (inside the actual combustion compartment as opposed to inside the exhaust flue) will even enable operators of small facilities, such as 5 kW and smaller power plants with coal boilers, to improve their monitoring of the combustion process and achieve significant energy savings, estimated² at between 2–10%, by optimizing the air-fuel ratio and fuel oil viscosity. Such monitoring and energy savings were not previously possible or cost-effective due to the lack of available sensor robustness and the high cost of sensors requiring external air supplies.

Commercialization

This technology was awarded an R&D 100 Award in 2005. Several suppliers have expressed significant commercial interest in the technology, including Air Products and Chemicals, Inc., Analytical Specialties, Inc., Makel Engineering, Inc., General Electric, Texas Instruments, and Dow. These organizations have a variety of applications in mind for the oxygen sensor, including chemical and petrochemical plants, pulp and paper processing, blast furnaces, glass furnaces, internal combustion engines, and environmental monitoring of exhaust gases. With regard to the last application, the sensor may be modified in the future to detect nitrogen oxides, carbon monoxide, and carbon dioxide.

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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

¹ Taken from the 2005 R&D Award Entry by Ohio State University for the "High Temperature Potentiometer Oxygen Sensor with Internal Reference."

² "Oikos Boiler Testing, Economics." 2004, Iris Communications.