



## Technology Focus: Sensors

### **Amperometric Solid Electrolyte Oxygen Microsensors With Easy Batch Fabrication**

**These microsensors are applicable to fire detection, environmental monitoring, fuel leak detection, and engine emission monitoring.**

*John H. Glenn Research Center, Cleveland, Ohio*

There is a great need for oxygen microsensors for aerospace and commercial applications. Current bulk or thick-film solid electrolyte oxygen sensors have the disadvantages of being large in size, high in power consumption, difficult to batch-fabricate, and high in cost.

An amperometric solid electrolyte oxygen (O<sub>2</sub>) microsensor using a novel and robust structure has been developed with a detection range of 0.025 to 21 percent of O<sub>2</sub> concentration. The microsensor has a simple structure with a sensing area of 1.10×0.99 mm<sup>2</sup>, and is operated by applying voltage across the electrodes and measuring the resulting current flow at a temperature of 600 °C.

Semiconductor microfabrication techniques are used in the sensor fabrication. The fabrication of oxygen microsensors includes two steps: deposition of platinum interdigitated finger electrodes, and deposition of yttria stabilized zirconia (YSZ) on the finger electrodes. The platinum interdigitated finger electrodes were deposited as follows: Alumina substrates (250 μm in thickness) were patterned with photoresist and an interdigitated finger elec-

trode photomask. A layer of 50 Å of titanium and a layer of 2,500 Å of platinum were deposited on the substrate by sputter deposition. After photoresist liftoff, the solid electrolyte YSZ was deposited on top of the electrode area by sputtering using a shadow mask. The sensor testing is conducted by applying a voltage to the electrodes and measuring the resulting current.

The novel and important aspect of the development is that, instead of applying an extra structure on top of the sensor surface, which involves very complicated fabrication processes, the YSZ itself is used as both a diffusion barrier and sensing layer. Therefore, a thicker YSZ layer than that used in other structures is deposited. The extra YSZ thickness prevents the sensor from being saturated by high concentrations of oxygen gases. This novel approach enabled a simpler sensor structure, easier batch fabrication process, higher sensor yield, and lower cost.

Another important aspect is that while the extra thickness of the YSZ is meant to be a diffusion barrier, it also contributes to the current output of the

sensor. By adjusting the YSZ thickness, different detection ranges can be achieved. At 7,500 Å, the sensor has a viable detection range of 0.025 to 16 percent, with a linear response to the logarithm of oxygen concentrations. By increasing the thickness of solid electrolyte YSZ to 2.6 μm, the O<sub>2</sub> detection range has been expanded to higher concentrations; an overall range of 0.025 to 21 percent is achieved.

The microsensor has a wide detection range and high current output considering its size. It can be integrated into a sensor array with other sensors and electronics, power, and telemetry on a postage-stamp-sized package as part of a smart sensor system.

*This work was done by Gary W. Hunter and Jennifer C. Xu of Glenn Research Center and Chung-Chium Liu of Case Western Reserve University. Further information is contained in a TSP (see page 1).*

*Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18592-1.*

### **Two-Axis Direct Fluid Shear Stress Sensor for Aerodynamic Applications**

**This microsensor, fabricated using MEMS technology to enable low-cost production, makes truly nonintrusive biaxial shear stress measurements.**

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This miniature or micro-sized semiconductor sensor design provides direct, nonintrusive measurement of skin friction or wall shear stress in fluid flow situations in a two-axis configuration. The sensor is fabricated by microelectromechanical system (MEMS) technology, enabling small size and multiple, low-cost reproductions. The sensors may be fabri-

cated by bonding a sensing element wafer to a fluid-coupling element wafer. Using this layered machine structure provides a truly three-dimensional device.

The sensor design (see figure) includes a shear-force collecting plate (fluid-coupling element) with dimensions tailored to application-determined resolutions (spatial, temporal,

and force). The plate is located coplanar to both the sensor body and flow boundary. This plate is coupled to a biaxial gimbal structure provided with piezoresistors on its torsional hinges, and, located parallel to but some distance from the force collection plate, with a connecting column. This design thus allows a nonintrusive method to