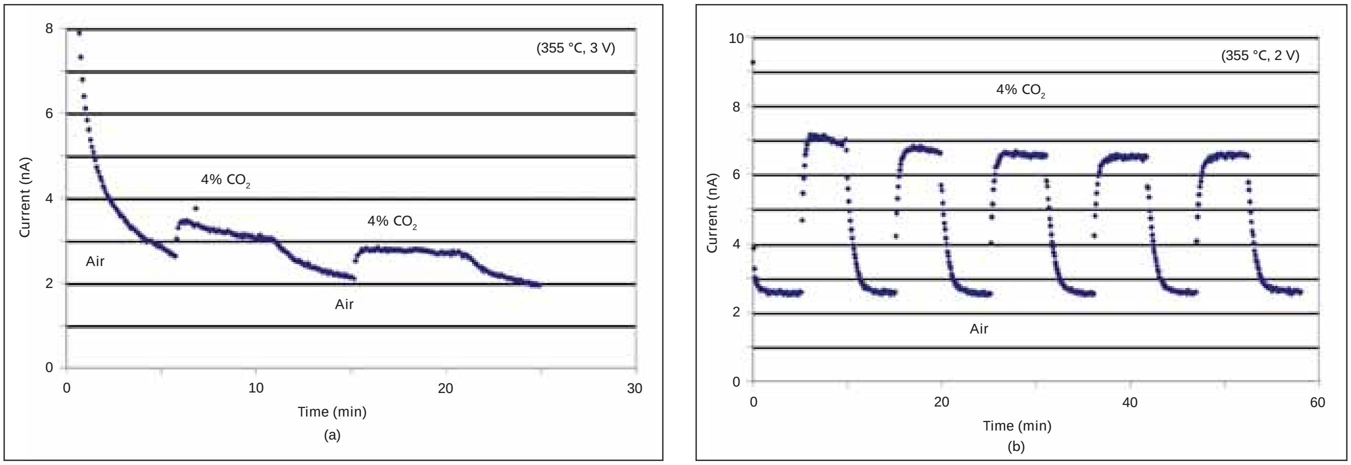


Figure 2. **The Current Response of a CO_2 Sensor** fabricated as described in the text was measured at an applied potential at a temperature of 355 °C. Figure 2(a) shows a CO_2 sensor response without a nanocrystalline SnO_2 coating, while Figure 2(b) shows a dramatic difference enabled by the addition of a coating of nanocrystalline SnO_2.

alumina substrate by use of standard techniques of sputter deposition, photolithography, and liftoff.

2. In a second process involving the use of standard techniques of sputter deposition, photolithography, and liftoff, the $Na_3Zr_2Si_2PO_{12}$ solid electrolyte is deposited mainly between (and touching) the platinum interdigitated electrodes.
3. The workpiece is heated to a temperature of 850 °C for 2 hours.
4. The Na_2CO_3:$BaCO_3$ auxiliary solid electrolyte is deposited on the electrodes and the $Na_3Zr_2Si_2PO_{12}$ solid electrolyte by sputtering through a shadow mask.
5. The workpiece is heated to 686 °C for 10 minutes, then to 710 °C for 20 minutes.
6. The layer of nanocrystalline SnO_2 is deposited on the Na_2CO_3:$BaCO_3$ layer by a sol-gel process.
7. The workpiece is heated to 500 °C for 2 hours.

The workpiece is then ready for use as an amperometric CO_2 sensor.

Research will continue to optimize CO_2 sensor performance, while decreasing the operating temperature and power consumption. The objective of future work is to decrease the power consumption to enable, for example, long-term battery operation of CO_2 sensor systems.

This work was done by Gary W. Hunter and Jennifer C. Xu of Glenn Research Center. 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: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18324-1

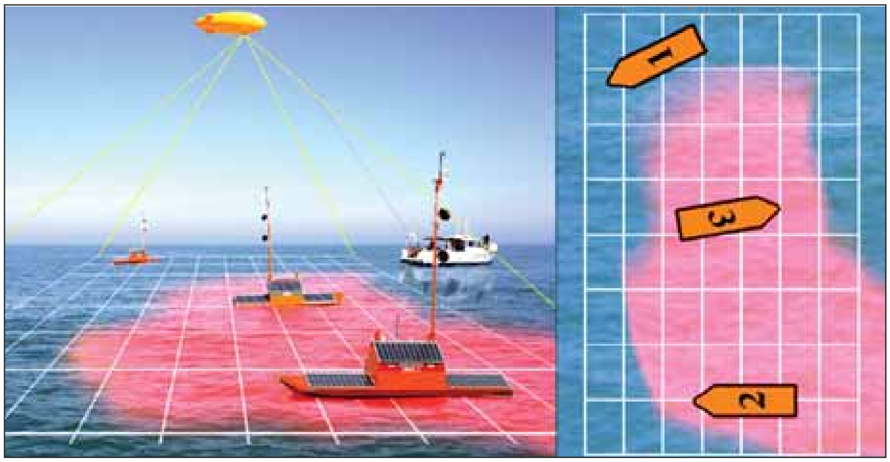
Tele-Supervised Adaptive Ocean Sensor Fleet

A software architecture and system deploys robotic boats to study ocean surface and subsurface phenomena such as coastal pollutants, oil spills, and hurricanes.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Tele-supervised Adaptive Ocean Sensor Fleet (TAOSF) is a multi-robot science exploration architecture and system that uses a group of robotic boats (the Ocean-Atmosphere Sensor Integration System, or OASIS) to enable *in-situ* study of ocean surface and subsurface characteristics and the dynamics of such ocean phenomena as coastal pollutants, oil spills, hurricanes, or harmful algal blooms (HABs). The OASIS boats are extended-deployment, autonomous ocean surface vehicles. The TAOSF architecture provides an integrated approach to multi-vehicle coordination and sliding human-vehicle autonomy.

One feature of TAOSF is the adaptive re-planning of the activities of the OASIS vessels based on sensor input



A concept of the **TAOSF Field Deployment System** shows an overhead aerostat (an unmanned blimp tethered to a manned field operations vessel) that provides a global camera overview of three OASIS platforms and a patch of rhodamine dye. The overhead map is shown on the right.

("smart" sensing) and sensorial coordination among multiple assets. The architecture also incorporates Web-based communications that permit control of the assets over long distances and the sharing of data with remote experts. Autonomous hazard and assistance detection allows the automatic identification of hazards that require human intervention to ensure the safety and integrity of the robotic vehicles, or of science data that require human interpretation and response. Also, the architecture is designed for science analysis of acquired data in order to perform an initial onboard assessment of the presence of specific science signatures of immediate interest.

TAOSF integrates and extends five subsystems developed by the participating institutions: Emergent Space Technologies, Wallops Flight Facility, NASA's Goddard Space Flight Center (GSFC), Carnegie Mellon University, and Jet Propulsion Laboratory (JPL). The OASIS Autonomous Surface Vehicle (ASV) system, which includes the vessels as well as the land-based control and communications infrastructure developed for them, controls the hardware of each platform (sensors, actuators, etc.), and also provides a low-level waypoint navigation capability. The Multi-Platform Simulation Environment from GSFC is a surrogate for the OASIS ASV system and allows for independent development and testing of higher-level software components. The Platform Communicator acts as a proxy for both actual and simulated platforms. It translates platform-independent messages from the higher control systems to the device-dependent communication protocols. This enables the higher-level control systems to interact identically with heterogeneous actual or simulated platforms.

The Adaptive Sensor Fleet (ASF) provides autonomous platform assignment and path planning for area coverage, as well as monitoring of mission progress. The System Supervision Architecture (SSA) provides high-level planning, monitoring, tele-supervision, and science data analysis. The latter is done using the Inference Grid (IG) framework to represent multiple spatially- and temporally-varying properties. The Inference Grid is a probabilistic multiproperty spatial lattice model, where sensor information is stored in spatially and temporally registered form, and which is used for both scientific inferences and for vehicle mission planning. The information in each Inference Grid cell is represented as a stochastic vector, and metrics such as entropy are used to measure the uncertainty in the IG. The IG is used for analysis of science data from both the OASIS platforms and external sources such as satellite imagery and fixed sensors. These data are used by the SSA in planning vessel navigational trajectories for data gathering. The SSA also provides an operator interface for those occasions when a scientist desires to exert direct monitoring and control of individual platforms and their instruments.

Using this architecture, multiple mobile sensing assets can function in a cooperative fashion with the operating mode able to range from totally autonomous control to tele-operated control. This increases the data-gathering effectiveness and science return while reducing the demands on scientists for tasking, control, and monitoring. This system is applicable also to areas where multiple sensing assets are needed like ecological forecasting, water management, carbon management, disaster management, coastal management, homeland security, and planetary exploration.

This work was done by Gregg W. Podnar and John M. Dolan of Carnegie Mellon Univeristy, Alberto Elfes of Caltech, and Jeffrey C. Hosler and Troy J. Ames of Goddard Space Flight Center for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-45478