

and there has been no wear since the prior measurement, then the present temperature can be determined from the present resonance frequency.

The lower part of the figure depicts another sensor of the present type, containing multiple sets of interdigitated elec-

trodes embedded parallel to the wearing surface in a configuration such that the number of electrode pairs, and thus the capacitance, decreases with the depth of wear. Optionally, one or more of the sets of interdigitated electrodes can be embedded along with a temperature-sensi-

tive dielectric material to obtain a temperature-measurement capability.

*This work was done by Stanley E. Woodard of Langley Research Center and Bryant D. Taylor of Swales Aerospace. Further information is contained in a TSP (see page 1). LAR-16591-1*

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## Processing Nanostructured Sensors Using Microfabrication Techniques

**Nanostructured sensors have uses in safety, environmental monitoring, fire detection, and security.**

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

Standard microfabrication techniques can be implemented and scaled to help assemble nanoscale microsensors. Currently nanostructures are often deposited onto materials primarily by adding them to a solution, then applying the solution in a thin film. This results in random placement of the nanostructures with no controlled order, and no way to accurately reproduce the placement. This method changes the means by which microsensors with nanostructures are fabricated. The fundamental advantage to this approach is that it enables standard microfabrication techniques to be applied in the repeated manufacture of nanostructured sensors on a microplatform.

The fundamental steps are first to define a standard metal electrode pattern of interdigitated fingers with parallel fingers that are saw-toothed. Nanostructures are then added to a standard photoresist to form a dilute solution. The photoresist solution is then applied to

the microstructure. Before the solution solidifies, alternating electric fields are applied across the electrodes in order to align the nanostructures on the wafer. Once this photoresist later dries into a film and is processed, a second layer of metal is deposited on top of the first layer. The effect is to remove photoresist from the metal fingers, but leave the nanostructures that bridge the fingers to be held in place by the top metal layer. Longer nanostructures, which are already aligned across the fingers, will be held in place by the top metal.

This buries the contacts of the nanostructures that are bridging the fingers between two layers of metal. The result is a microsensor fabricated using microfabrication techniques with aligned nanostructures bridging the electrodes and buried electrical contacts.

Possible applications include emissions monitoring, leak detection, engine monitoring, security, fire detection, extra-vehicular-activity (EVA)

applications, personal health monitoring, and environmental monitoring. Because this process is compatible with low temperatures and thin-film supports, it can be used in thin films for conductive coatings requiring electrical connections.

A proof-of-concept of this approach was demonstrated using alumina as the substrate, metals such as platinum as the bottom electrode and titanium as the top metal layer, and both multiwalled carbon nanotubes and metal oxide nanowires as the nanostructured material.

*This work was done by Gary W. Hunter, Randall L. VanderWal, Laura J. Evans, 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-18418-1.*

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## Optical Pointing Sensor

**The sensor can be used as a digitizer of physical objects to extract shape data.**

*NASA's Jet Propulsion Laboratory, Pasadena, California*

The optical pointing sensor provides a means of directly measuring the relative positions of JPL's Formation Control Testbed (FCT) vehicles without communication. This innovation is a steerable infrared (IR) rangefinder that gives measurements in terms of range and bearing to a passive retroreflector. Due to its reduced range of motion, the range and bearing measurements are on the order of 10 times

better than those of the existing sensor system.

The retroreflector is placed on one robot, and the rangefinder and steering optics are on another robot. The measurements are available on the rangefinder-mounted robot, giving it relative position knowledge to the retroreflector.

The system is composed of an HeNe pointing laser, a SICK IR laser

rangefinder, a two-axis fast steering mirror, a shear sensor, and a far-field retroreflector (see figure). The pointing laser is injected into the optical path using a beam splitter and bounces off the steering mirror toward the retroreflector. If the retroreflector is hit by the pointing laser, the beam is returned with the exact opposite direction. When the beam impact with the retroreflector is non-central,