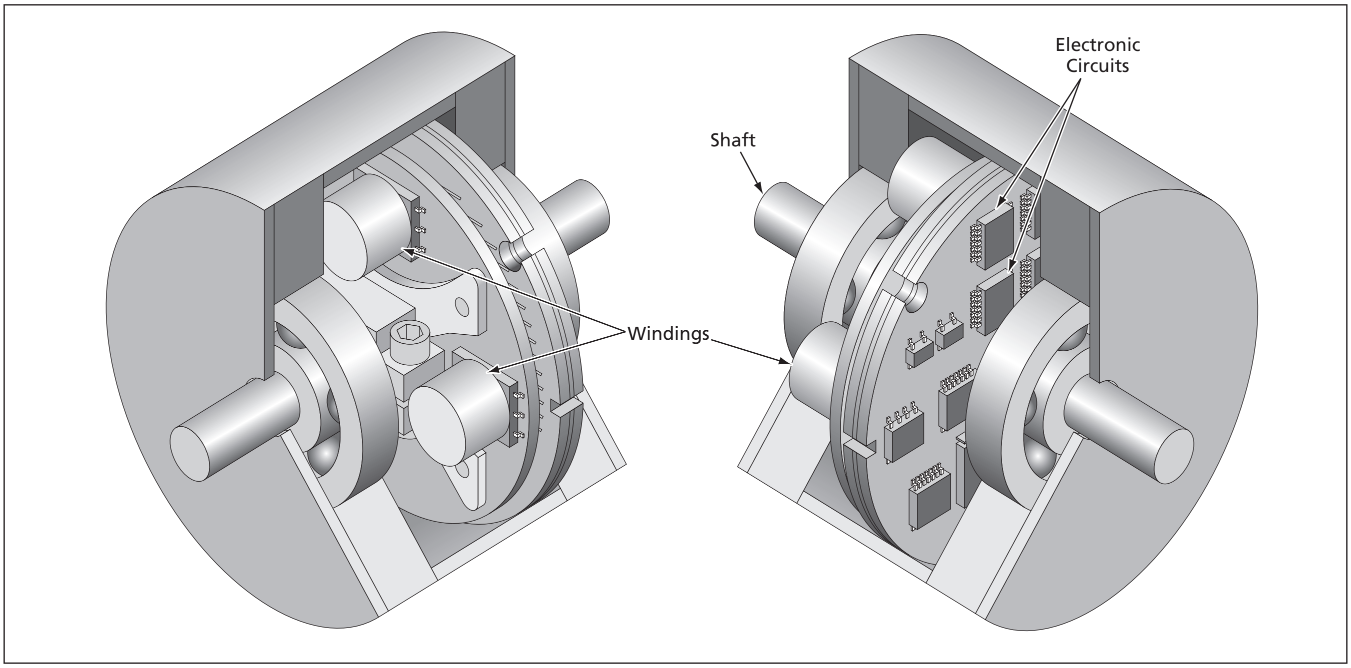


Transducers and Readout Electronic Circuits are parts of a sensor assembly contained in a single housing.

ment is the major difference between this unit and prior rotation-sensor units.

The sensor assembly inside the housing includes excitatory and readout integrated circuits mounted on a circular printed-circuit board. In a typical case in which the angle or speed transducer(s) utilize electromagnetic induction, the assembly also includes another circular printed-circuit board on which the transducer windings are mounted. A sheet of high-magnetic-permeability metal ("mu metal") is placed between the winding board and the electronic-circuit board to prevent spurious coupling of excitatory signals from the transducer windings to the readout circuits.

The housing and most of the other mechanical hardware can be common to a variety of different sensor designs. Hence, the unit can be configured to generate any of variety of outputs by changing the interior sensor assembly. For example, the sensor assembly could contain an analog tachometer circuit that generates an output proportional (in both magnitude and sign or in magnitude only) to the speed of rotation.

This work was done by Dean C. Alhorn, David E. Howard, and Dennis A. Smith of **Marshall Space Flight Center**. *Further information is contained in a TSP (see page 1).*

This invention has been patented by NASA (U.S. Patent No. 6,313,624). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31238.

Arrays of Nano Tunnel Junctions as Infrared Image Sensors

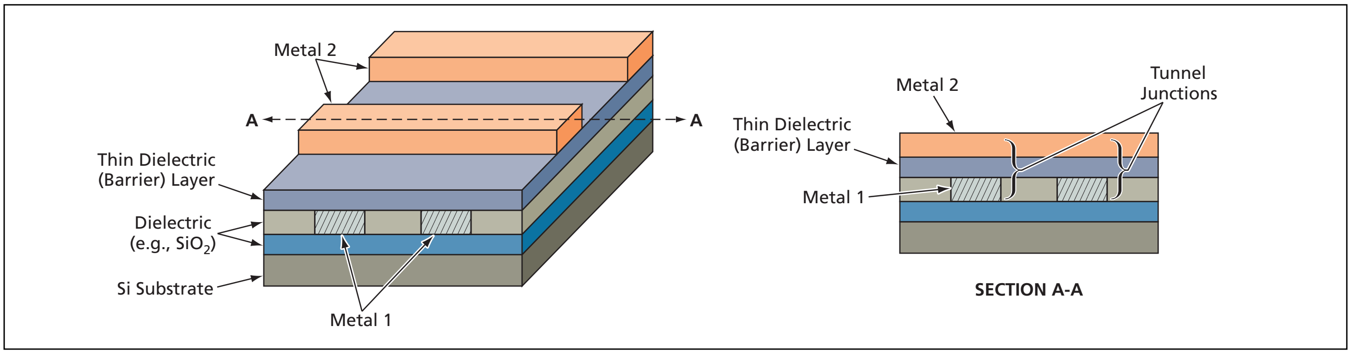
High detectivity and rapid response would be attainable at room temperature.

NASA's Jet Propulsion Laboratory, Pasadena, California

Infrared image sensors based on high-density rectangular planar arrays of nano tunnel junctions have been proposed. These sensors would differ fundamentally from prior infrared sensors based, variously, on bolometry or conventional semiconductor photodetection.

Infrared image sensors based on conventional semiconductor photodetection must typically be cooled to cryogenic temperatures to reduce noise to acceptably low levels. Some bolometer-type infrared sensors can be operated at room temperature, but they exhibit low detectivities and long response times, which limit their utility. The proposed infrared image sensors could be operated at room temperature without incurring excessive noise, and would exhibit high detectivities and short response times. Other advantages would include low power demand, high resolution, and tailorability of spectral response.

Neither bolometers nor conventional semiconductor photodetectors, the basic detector units as proposed would partly resemble rectennas. Nanometer-scale tunnel junctions would be created by crossing of nanowires with quantum-mechanical-barrier layers in the form of thin layers of electrically insulating material between them (see figure). A microscopic dipole antenna sized and shaped to respond maximally in the infrared wavelength range that one seeks to detect would be formed integrally with the nanowires at each junction. An incident signal in that wavelength range would become coupled into the antenna and, through the antenna, to the junction. At the junction, the flow of electrons between the crossing wires would be dominated by quantum-mechanical tunneling rather than thermionic emission. Rela-



Crossed Nanowires with dielectric barriers between them would constitute quantum-mechanical-tunneling junctions that could be used to detect infrared radiation. This device would be fabricated by a process including electron-beam lithography, deposition of metal, and etching. For simplicity, antennas that would be formed integrally with the nanowires are omitted.

tive to thermionic emission, quantum-mechanical tunneling is a fast process. As described below, the quantum-mechanical tunneling would be exploited to rectify the infrared-frequency alternating signal delivered to the junction from the antenna.

Each nanojunction would be asymmetrical in that the crossing nanowires would be made of two different materials: for example, two different metals, a metal and semiconductor, or the same semiconductor doped at two different levels. The resulting asymmetry and nonlinearity of the tunneling current as a function of voltage across the junction could be exploited to effect rectification of the signal. Because the asymmetry would be present even in the absence of bias, the device could be operated at low or zero bias and, therefore, would demand very little power.

Other advantages of the proposed sensors would include the following:

- High spatial resolution would be achieved by virtue of the density of nanowires and, consequently, of nanojunctions.
- The barriers are expected to keep dark currents very small, leading to high signal-to-noise ratios.
- Different nanojunctions within the same sensor could be fabricated with antennas tailored for different wavelengths, enabling multispectral imaging.

This work was done by Kyung-Ah Son of Caltech; Jeong S. Moon of HRL, LLC; and Nicholas Prokopuk of Naval Air Warfare Center for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Innovative Technology Assets Management
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov

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Catalytic-Metal/PdO_x/SiC Schottky-Diode Gas Sensors

PdO_x layers inhibit the undesired formation of metal silicides.

John H. Glenn Research Center, Cleveland, Ohio

Miniaturized hydrogen- and hydrocarbon-gas sensors, heretofore often consisting of Schottky diodes based on catalytic metal in contact with SiC, can be improved by incorporating palladium oxide (PdO_x, where $0 \le x \le 1$) between the catalytic metal and the SiC.

In prior such sensors in which the catalytic metal was the alloy PdCr, diffusion and the consequent formation of oxides and silicides of Pd and Cr during operation at high temperature were observed to cause loss of sensitivity. However, it was also observed that any PdO_x layers that formed and remained at PdCr/SiC interfaces acted as barriers to diffusion, preventing further deterioration by preventing the subsequent formation of metal silicides.

In the present improvement, the lesson learned from these observations is applied by placing PdO_x at the catalytic-metal/SiC interfaces in a controlled and uniform manner to form stable diffusion barriers that prevent formation of metal silicides. A major advantage of PdO_x over other candidate diffusion-barrier materials is that PdO_x is a highly stable oxide that can be incorporated into gas-sensor structures by use of deposition techniques that are standard in the semiconductor industry.

The PdO_x layer can be used in a gas sensor structure for improved sensor stability, while maintaining sensitivity. For example, in proof-of-concept experiments, Pt/PdO_x/SiC Schottky-diode gas sensors were fabricated and tested. The fabrication process included controlled sputter deposition of PdO_x to a thickness of ≈50 Å on a 400-µm-thick SiC substrate, followed by deposition of Pt to a thickness of ≈450 Å on the PdO_x. The SiC substrate (400 microns in thickness) was patterned with photoresist and a Schottky-diode photomask. A lift-off process completed the definition of the Schottky-diode pattern.

The sensors were tested by measuring changes in forward currents at a bias potential of 1 V during exposure to H_2 in N_2 at temperatures ranging from 450 to 600 °C for more than 750 hours. The sensors were found to be stable after a break-in time of nearly 200 hours. The sensors exhibited high sensitivity: sensor currents changed by factors ranging from 300 to 800 when the gas was changed from pure N_2 to 0.5 percent H_2 in N_2. The high sensitivity and stability of these Pt/PdO_x/SiC sensors were found to represent a marked improvement over comparable Pt/SiC sensors. More-