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 tailorable 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.

Catalytic-Metal/PdO\textsubscript{x}/SiC Schottky-Diode Gas Sensors

PdO\textsubscript{x} layers inhibit the undesired formation of metal silicides.

John H. Glenn Research Center, Cleveland, Ohio

Miniaturized hydrogen- and hydrocarbon-gas sensors, heretofore consisting of Schottky diodes based on catalytic metal in contact with SiC, can be improved by incorporating palladium oxide (PdO\textsubscript{x}, where 0\textless x\textless 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\textsubscript{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\textsubscript{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\textsubscript{x} over other candidate diffusion-barrier materials is that PdO\textsubscript{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\textsubscript{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\textsubscript{x}/SiC Schottky-diode gas sensors were fabricated and tested. The fabrication process included controlled sputter deposition of PdO\textsubscript{x} to a thickness of \approx 50 Å on a 400-μm-thick SiC substrate, followed by deposition of Pt to a thickness of \approx 450 Å on the PdO\textsubscript{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\textsubscript{2} in N\textsubscript{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\textsubscript{2} to 0.5 percent H\textsubscript{2} in N\textsubscript{2}. The high sensitivity and stability of these Pt/PdO\textsubscript{x}/SiC sensors were found to represent a marked improvement over comparable Pt/SiC sensors. More...