The mechanism by which the sensing occurs is enabled by the reduced dimensionality for phonon scattering in 1D systems — in particular, suspended SWNTs — which can cause unique effects to arise at large bias voltages and power. Such effects are completely absent in 2D or 3D conductors such as within the filament of a conventional Pirani gauge. In suspended SWNTs at high fields, a large non-equilibrium optical phonon population exists, and their long relaxation times result in non-isothermal conditions along the length of the tube. In unsuspended tubes, the I-V characteristic increases monotonically at high voltages suggestive of isothermal conditions, since the substrate facilitates in the relaxation of optical phonons emitted through electron scattering. In contrast, the current in the suspended tube saturates and a negative differential conductance (NDC) regime is encountered, which cannot be explained by velocity saturation (at –5 kV/cm). This is a signature of the effective temperature rise within the tube that can be used to enhance sensitivity for gas detection. The large optical phonon density in suspended SWNTs at high fields with long lifetimes may play an important role in determining the rate of temperature rise in the tubes, which can be exploited maximally for their utility as thermal conductivity-based gas sensors.

The method used to form suspended long (>5 μm) SWNTs is novel and has not been reported in the past. A dry release technique is used based on critical-point drying. In the past, the reduced surface tension of various solvents has been used; however, these are all based on wet processes that will inherently suffer to a larger extent from capillary forces upon release.

The SWNT-based chemical sensor described here could be useful for future NASA astrobiology missions to detect specific biomarkers in the gaseous phase or to decipher biological activity by measuring outgassing rates; for example, within microcavities. The sensor could be used in future NASA instruments that require gas chromatographs to identify chemical species in planetary atmospheres, as well as future Lander missions.

The sensor could also be used aboard NASA spacecraft or instruments as a low-power, low-mass, compact leak detector with a fast response time compared to conventionally used thermal-conductivity-based leak detectors such as the Pirani gauge.

This work was done by Anupama B. Kaul of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

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:

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Refer to NPO-46844, volume and number of this NASA Tech Briefs *issue, and the page number.*

Aerogel-Positronium Technology for the Detection of Small Quantities of Organic and/or Toxic Materials

Potential applications range from life detection and human life support, to sample return missions.

NASA's Jet Propulsion Laboratory, Pasadena, California

The Ps-aerogel system [Ps is positronium (an electron-positron-hydrogen-like atom)] has been evaluated and optimized as a potential tool for planetary exploration missions. Different configurations of use were assessed, and the results provide a quantitative measure of the expected performance. The aerogel density is first optimized to attain maximum production of Ps that reaches the pores of the aerogel. This has been accomplished, and the optimum aerogel density is ≈70 mg/cm^3. The aerogel is used as a concentrator for target volatile moieties, which accumulate in its open porosity over an extended period of time. For the detection of the accumulated materials, the use of Ps as a probe for the environment at the pore surface, has been proposed.

This concept is based on two steps: (1) using aerogel to produce Ps and (2) using the propensity of Ps to interact differently with organic and inorganic matter. The active area of such a detector will comprise aerogel with a certain density, specific surface area, and gas permeability optimized for Ps production and gas diffusion and adsorption. The aerogel is a natural adsorber of organic molecules, which adhere to its internal surface, where their presence is detected by the Ps probe. Initial estimates indicate that, e.g., trace organic molecules in the Martian atmosphere, can be detected at the ppm level, which rivals current methods having significantly higher complexity, volume, mass, and power consumption (e.g. Raman, IR).

This method carries important benefits in working toward NASA/JPL goals, and has the potential to advance organic detection capabilities. It is intended to work toward feasibility studies. At the same time, it is recognized that a full-scale investigation will profit enormously from an achieved optimization of the aerogel microstructure for Ps production and gas percolation.

The Ps-aerogel system provides an entirely new approach toward sensing of trace volatile components in vacuum or in the atmosphere. Contrary to all other conventional methods, which use "momentary sensing" and analyzing the content, the Ps-aerogel system relies on a continuous passive exposure to the environment. An instrument built on this new technology will be lightweight, small in size, and will not consume power during accumulation. In testing, the adsorption of simple organic materials, such as alcohols, naphthalene, etc, has been detected. Also, with the optimization of the Ps-aerogel system, a number of other applications, ranging from thermal insulation to charge storage systems, have been discovered.

This work was done by Mihail P. Petkov and Steven M. Jones of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). ***NPO-46762***