sion is said to be micromachined because the two silicone layers containing the channels would be fabricated by casting silicone rubber on micromachined silicon molds.

The pneumatic-actuation channels would be alternately connected to a compressed gas and (depending on pump design) either to atmospheric pressure or to a partial vacuum source. The design would be such that the higher pneumatic pressure would be sufficient to push the silicone arches down onto the substrates, blocking the channels. Thus, by connecting pneumatic-actuation channels to the two pneumatic sources in spatial and temporal alternation, waves of opening and closing, equivalent to peristalsis, could be made to move along the pump channels.

A pump according to this concept could be manufactured inexpensively. Pneumatic sources (compressors and partial vacuum sources) similar those needed for actuation are commercially available; they typically have masses of ≈100 g and power demands of the order of several W. In a design-optimization effort, it should be possible to reduce masses and power demands below even these low levels and to integrate pneumatic sources along with the proposed pumps into miniature units with overall dimensions of no more than a few centimeters per side.

This work was done by Sabrina Feldman, Jason Feldman, and Danielle Svehla of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com***.
NPO-30165

Miniature Gas-Turbine Power Generator

Energy density would greatly exceed that of a typical battery system.

NASA's Jet Propulsion Laboratory,
Pasadena, California

A proposed microelectromechanical system (MEMS) containing a closed-Brayton-cycle turbine would serve as a prototype of electric-power generators for special applications in which high energy densities are required and in which, heretofore, batteries have been used. The system would have a volume of about 6 cm^3 and would operate with a thermal efficiency >30 percent, generating up to 50 W of electrical power. The energy density of the proposed system would be about 10 times that of the best battery-based systems now available, and, as such, would be comparable to that of a fuel cell.

The working gas for the turbine would be Xe containing small quantities of CO_2, O_2, and H_2O as gaseous lubricants. The gas would be contained in an enclosed circulation system, within which the pressure would typically range between 5 and 50 atm (between 0.5 and 5 MPa). The heat for the Brayton cycle could be supplied by any of a number of sources, including a solar concentrator or a combustor burning a hydrocarbon or other fuel. The system would include novel heat-transfer and heat-management components. The turbine would be connected to an electric power generator/starter motor.

The system would include a main rotor shaft with gas bearings; the bearing surfaces would be made of a ceramic material coated with nanocrystalline diamond. The shaft could withstand speed of 400,000 rpm or perhaps more, with bearing-wear rates less than $10^{-4}\times$ those of silicon bearings and 0.05 to 0.1× those of SiC bearings, and with a coefficient of friction about 0.1× that of Si or SiC bearings. The components of the system would be fabricated by a combination of (1) three-dimensional x-ray lithography and (2) highly precise injection molding of diamond-compatible metals and ceramic materials. The materials and fabrication techniques would be suitable for mass production.

The disadvantages of the proposed system are that unlike a battery-based system, it could generate a perceptible amount of sound, and, if it were to burn fuel, then it would also generate exhaust, similarly to other combustion-based power sources.

This work was done by Dean Wiberg, Stephen Vargo, Victor White, and Kirill Shcheglov of Caltech and Philip Muntz of the University of Southern California for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com***.
NPO-20933