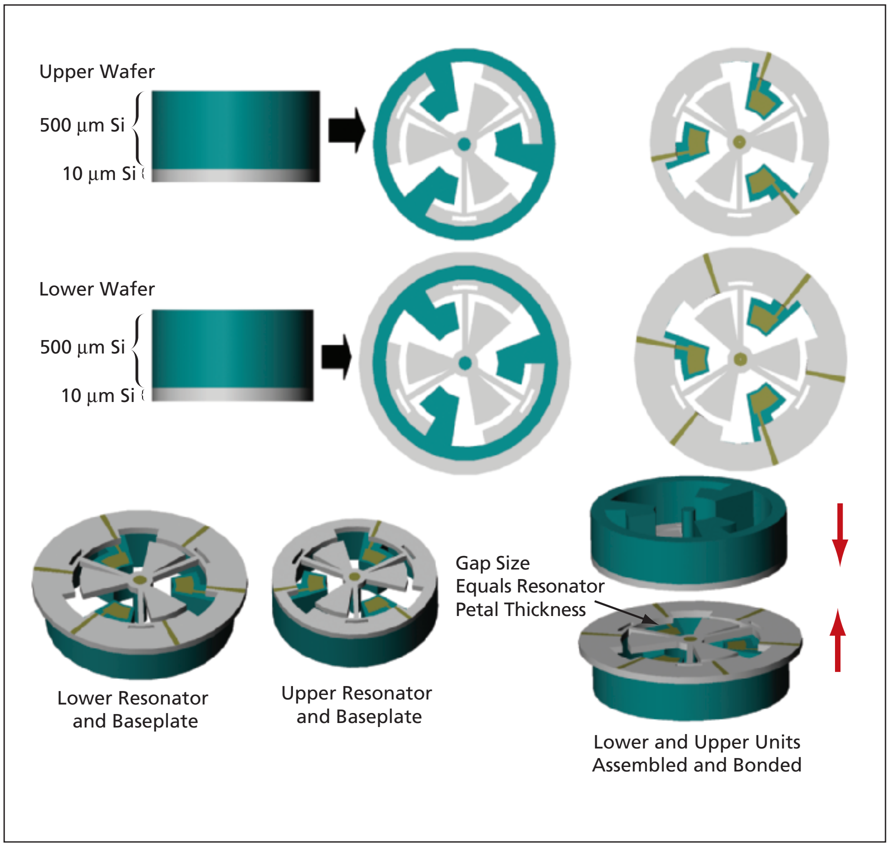

A **Split-Resonator, Integrated-Post Vibratory Microgyroscope** is made in upper and lower parts that are micromachined from two wafers, then bonded together.

essary to disconnect the lower half post from the baseplate. For mass production, it would be desirable to effect this disconnection by etching away the post support on the baseplate, but it is difficult to perform such an etch without damaging the microgyroscope, which, except for this etch, is complete at this stage. Therefore, instead of etching, it has proved necessary to perform ablation of individual supports, which entails processing time proportional to the number of microgyroscopes on a wafer. The improved design eliminates the need for ablation of individual supports, thereby correspondingly reducing processing time.

In the improved design (see figure), a resonator is split into an upper and a lower half, which are micromachined out of an upper and a lower wafer, respectively. A baseplate (which supports the resonator and is the relatively stationary object with respect to which the resonator vibrates) is likewise split into upper and lower halves. The upper and lower half resonators are offset from each other such that when the micromachined wafers are assembled and bonded together, the petals of the upper half resonator hang over electrodes on the lower half baseplate, while the petals of the lower half resonator hang over electrodes on the upper half baseplate. The capacitive gaps between the resonator petals and the baseplate are formed by opposing thicknesses of the half resonators.

This work was done by Youngsam Bae, Ken Hayworth, and Kirill Shcheglov of Caltech 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:

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Blended Buffet-Load-Alleviation System for Fighter Airplane

Reductions in buffet loads translate to longer fatigue lives.

Langley Research Center, Hampton, Virginia

The capability of modern fighter airplanes to sustain flight at high angles of attack and/or moderate angles of sideslip often results in immersion of part of such an airplane in unsteady, separated, vortical flow emanating from its forebody or wings. The flows from these surfaces become turbulent and separated during flight under these conditions. These flows contain significant levels of energy over a frequency band coincident with that of low-order structural vibration modes of wings, fins, and control surfaces. The unsteady pressures applied to these lifting surfaces as a result of the turbulent flows are commonly denoted buffet loads, and the resulting vibrations of the affected structures are known as buffeting. Prolonged exposure to buffet loads has resulted in fatigue of structures on several airplanes. Damage to airplanes caused by buffeting has led to redesigns of airplane structures and increased support costs for the United States Air Force and Navy as well as the armed forces of other countries. Time spent inspecting, repairing, and replacing structures adversely affects availability of aircraft for missions.

A blend of rudder-control and piezoelectric-actuator engineering concepts was selected as a basis for the design of a vertical-tail buffet-load-alleviation system for the F/A-18 airplane. In this system, the rudder actuator is used to control the response of the first tail vibrational mode (bending at a frequency near 15 Hz), while directional patch piezoelectric actuators are used to control the second tail vibrational mode (tip torsion at a frequency near

45 Hz). This blend of two types of actuator utilizes the most effective features of each.

An analytical model of the aeroservoelastic behavior of the airplane equipped with this system was validated by good agreement with measured results from a full-scale ground test, flight-test measurement of buffet response, and an in-flight commanded rudder frequency sweep. The overall performance of the system was found to be characterized by reductions, ranging from 70 to 30 percent, in vertical-tail buffeting under buffet loads ranging from moderate to severe. These reductions were accomplished with a maximum commanded rudder angle of ±2° at 15 Hz and about 10 lb (≈4.5 kg) of piezoelectric actuators attached to the vertical tail skin and operating at a peak power level of 2 kW. By meeting the design objective, this system would extend the vertical-tail fatigue life beyond two aircraft lifetimes. This system is also adaptable to other aircraft surfaces and other aircraft.

This work was done by Robert W. Moses of **Langley Research Center**. *For further information, contact the Intellectual Property Team at (757) 864-3521.*
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