



⊕ Fast Laser Shutters With Low Vibratory Disturbances

Opposing cantilevered piezoelectric bending actuators balance each other to minimize vibration.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure shows a prototype vacuum-compatible, fast-acting, long-life shutter unit that generates very little vibratory disturbance during switching. This is one of a number of shutters designed to satisfy requirements specific to an experiment, to be performed aboard a spacecraft in flight, in which laser beams must be blocked rapidly and completely, with-

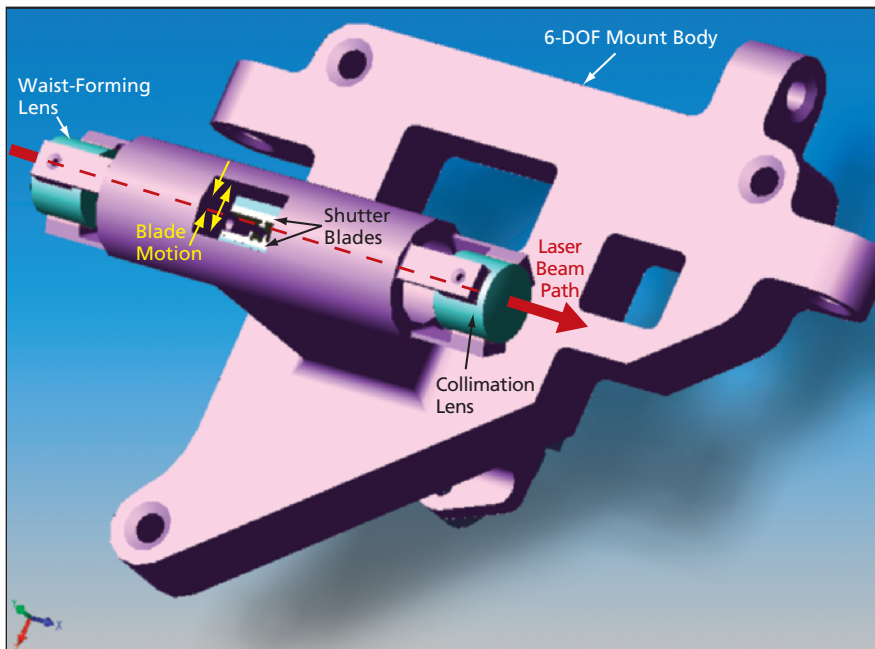
out generating a vibratory disturbance large enough to adversely affect the power and frequency stability of the lasers. Commercial off-the-shelf laboratory shutter units — typically containing electromagnetic-coil-driven mechanisms — were found not to satisfy the requirements because they are not vacuum-compatible, their actuators engage in uncompensated

motions that generate significant vibrations, and their operational lifetimes are too short. Going beyond the initial outer-space application, the present vacuum-compatible, fast-acting, long-life shutter units could also be used in terrestrial settings in which there are requirements for their special characteristics.

In designing these shutter units, unbalanced, electromagnetically driven mechanisms were replaced with balanced mechanisms that include commercial piezoelectric bending actuators. In each shutter unit, the piezoelectric bending actuators are configured symmetrically as opposing cantilever beams within a housing that contains integral mounts for lenses that focus a laser beam to a waist at the shutter location. In operation, the laser beam is blocked by titanium blades bonded near the free ends of the piezoelectric benders. The benders are driven by shaped electrical pulses with a maximum voltage differential of less than 60 V. Preliminary measurements indicate that rise and fall times are less than 1 ms.

This work was done by David Brinza, Donald Moore, Eric Hochberg, Tom Radey, and Albert Chen of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-40151.



The **Prototype Shutter Unit** contains titanium blades on the tips of opposing cantilever-beam piezoelectric bending actuators inside a housing. Lenses to focus a laser beam to a waist are mounted on the outside of the housing. The housing shown permits fine adjustment of the laser shutter in six degrees of freedom within the laser optical bench of the flight experiment.

⊕ Split-Resonator, Integrated-Post Vibratory Microgyroscope

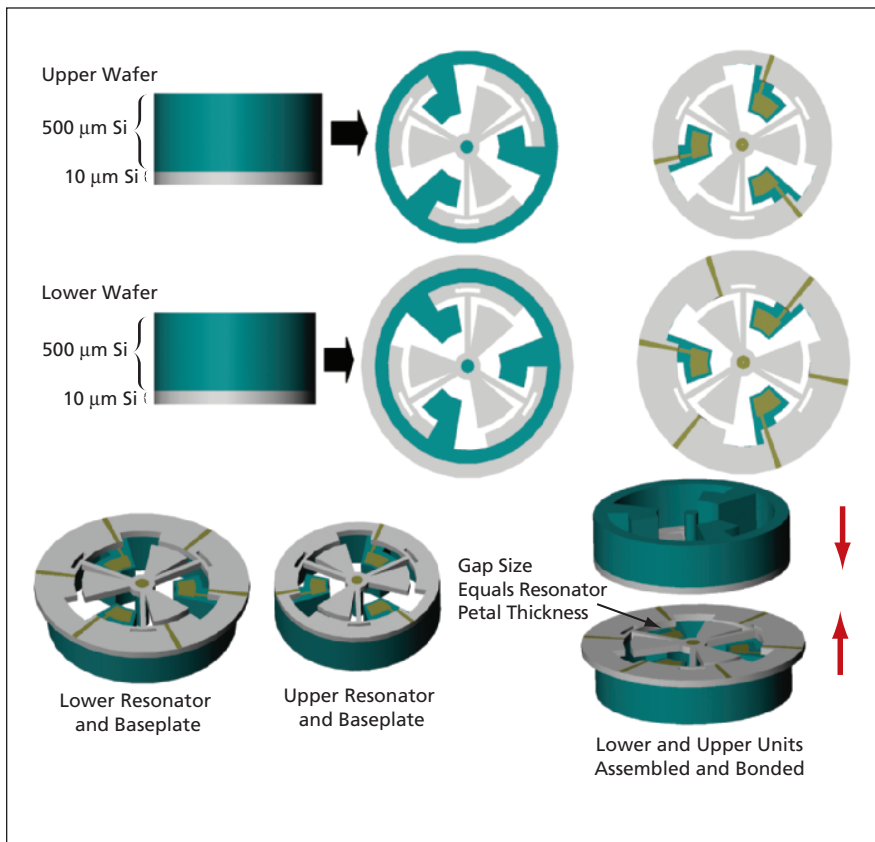
This design is better suited to mass production.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved design for a capacitive-sensing, rocking-mode vibratory microgyroscope is more amenable to mass production, relative to a prior design. Both the improved design and the prior design call for a central post that is part of a resonator that partly resembles a cloverleaf or a flower. The prior design is such that the post has to be fabricated

as a separate piece, then bonded to the rest of the resonator in the correct position and orientation. The improved design provides for fabrication of the post as an integral part of the resonator and, in so doing, makes it possible to produce a waferful of microgyroscopes, without need to fabricate, position, and attach posts.

The improved design offers an additional advantage over the prior design with respect to the fact that the prior design calls for the post to be fabricated in upper and lower halves. The lower half post is fabricated as part of a baseplate in a lower wafer that is subsequently bonded to an upper wafer. Once the wafers are bonded, it is nec-



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 reduc-

ing 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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Refer to NPO-30613, volume and number of this NASA Tech Briefs issue, and the page number.

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