particles in a laboratory fluidized bed reactor and used to compute yields of reaction products (especially tar). The results indicate that at fixed initial particle size, the temperature of the fluidizing gas is the foremost parameter that influences the tar yield and can be chosen to maximize the tar yield (see figure). The temperature of the biomass feed, the nature of the feedstock, and the fluidization velocity were all found to exert only minor effects on the tar yield.

This work was done by Josette Bellan and Danny Lathouwers of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*
NPO-30163

Membrane Mirrors With Bimorph Shape Actuators

Only modest control voltages would be needed.

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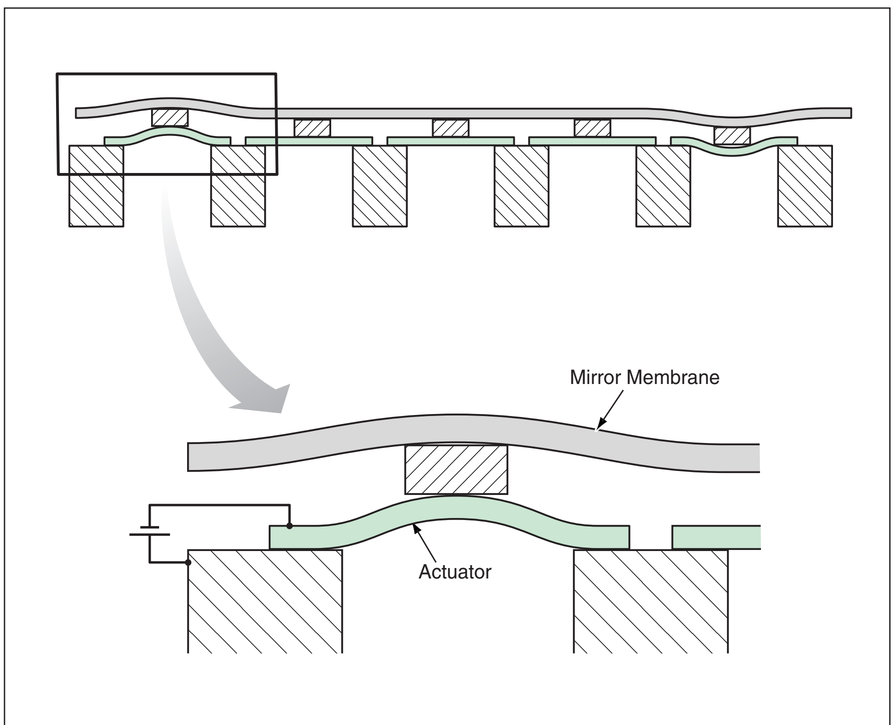
Deformable mirrors of a proposed type would be equipped with relatively-large-stroke microscopic piezoelectric actuators that would be used to maintain their reflective surfaces in precise shapes. These mirrors would be members of the class of MEMS-DM (for microelectromechanical system deformable mirror) devices, which offer potential for a precise optical control in adaptive-optics applications in such diverse fields as astronomy and vision science.

In some respects, the proposed mirrors would be similar to the ones described in "Silicon Membrane Mirrors With Electrostatic Shape Actuators" (NPO-21120) *NASA Tech Briefs*, Vol. 27, No. 1 (January 2003), page 62. Like a mirror of the type reported previously, a mirror as proposed here would include a continuous-membrane reflector attached by posts to actuators that, in turn, would be attached by posts to a rigid base (see figure). Also as before, the proposed mirror would be fabricated, in part, by use of a membrane-transfer technique. However, the actuator design would be different. Instead of the electrostatic actuators reported previously, the proposed mirror would contain bimorph-type piezoelectric actuators.

The reasons for the proposed choice of actuators are simple: In the mirror described in the cited prior article as well as in other previously reported membrane mirrors that feature piezoelectric and electrostrictive actuators, it is not possible, by use of modest actuation voltages, to obtain actuator strokes of the order of ±6 μm as needed in the intended adaptive-optics applications. The mechanical amplification inherent in the bimorph configuration would multiply the small displacements typically generated by piezoelectric devices, thereby making it possible to obtain the desired stroke magnitudes at voltages lower than would be needed to obtain the same stroke magnitudes from non-bimorph piezoelectric and electrostatic actuators.



This **Deformable Mirror** would contain bimorph actuators, which would produce relatively large strokes (≈6 μm) at modest applied potentials (≈9 V).

A voltage applied to the piezoelectric layer in a given actuator would induce a stress that would cause the actuator layer to bend and thus to pull or push on the mirror membrane. It has been estimated that an applied potential of ±9 V should be sufficient to produce an actuator stroke, and thus a local reflector displacement, of ±6 μm. Inasmuch as the actuators would be essentially capacitors from an electrical perspective, the actuators would consume power only during changes in their position settings. During maintenance of a position setting, only the supporting electronic circuitry would consume power.

This work was done by Eui-Hyeok Yang 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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