Fiber-Optic Ammonia Sensors

Reversible, colorimetric fiber-optic sensors are undergoing development for use in measuring concentrations of ammonia in air at levels relevant to human health [0 to 50 parts per million (ppm)]. A sensor of this type includes an optical fiber that has been modified by replacing a portion of its cladding with a polymer coat that contains a dye that reacts reversibly with ammonia and changes color when it does so. The change in color is measured as a change in the amount of light transmitted from one end of the fiber to the other. Responses are reversible and proportional to the concentration of ammonia over the range from 9 to 175 ppm and in some cases the range of reversibility extends up to 270 ppm. The characteristic time for the response of a sensor to rise from 10 to 90 percent of full scale is about 25 seconds. These sensors are fully operational in pure carbon dioxide and are not adversely affected by humidity.

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Silicon Membrane Mirrors With Electrostatic Shape Actuators

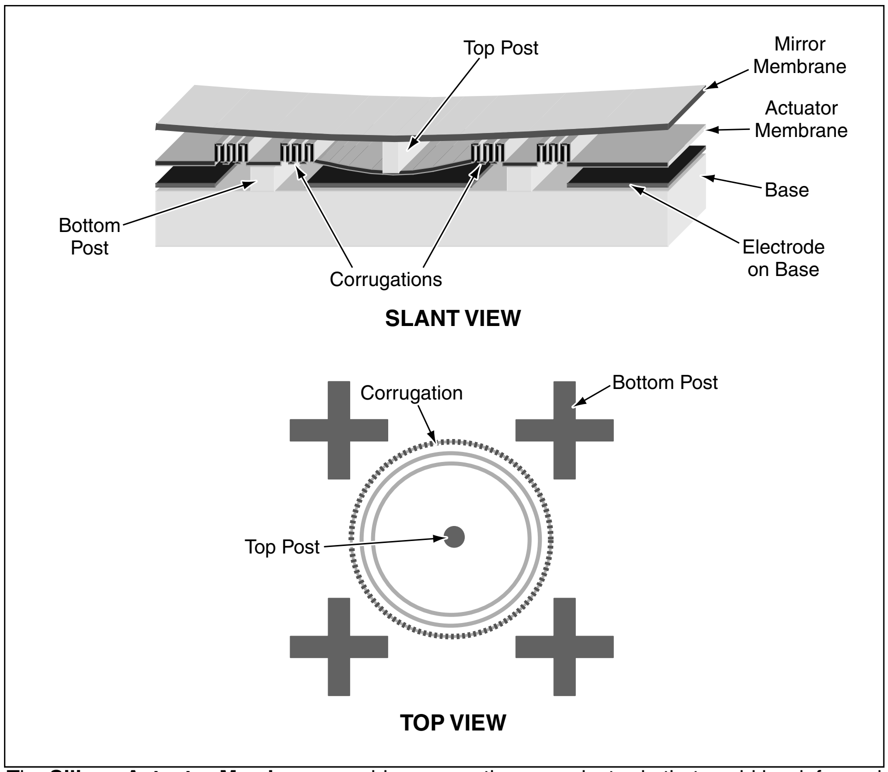
Precise shapes could be maintained over a wide temperature range.

NASA's Jet Propulsion Laboratory, Pasadena, California

Efforts are under way to develop deformable mirrors equipped with microscopic electrostatic actuators that would be used to maintain their reflective surfaces in precise shapes required for their intended applications. Unlike actuators that depend on properties of materials (e.g., piezoelectric and electrostrictive actuators), electrostatic actuators are effective over a wide temperature range. A mirror of the present type would be denoted a MEMS-DM (for microelectromechanical system deformable mirror). The reflective surface of such a mirror would be formed on a single-crystal silicon membrane that would be attached by posts to a silicon actuator membrane that would, in turn, be attached by posts to a rigid silicon base (see figure).

The actuator membrane would serve as the upper electrode of a capacitor. Multiple lower electrodes, each occupying a conveniently small fraction of the total area, would be formed on an electrically insulating oxide layer on the base, thereby defining a multiplicity of actuator pixels. The actuator membrane would be corrugated in a pattern that would impart mechanical compliance needed for relaxation of operational and fabrication-induced stresses and to minimize the degree of nonlinearity of deformations. The compliance afforded by the corrugations would also help to minimize the undesired coupling of deformations between adjacent pixels (a practical goal being to keep the influence coefficient between adjacent pixels below 10 percent).

The mirror and actuator membranes and posts would be fabricated partly by surface and partly by bulk micromachining of silicon. Other micromachining techniques that are in common use in the integrated-circuit industry could be used to integrate driver and control electronic circuits into the actuator structure. The base, actuator, and mirror layers would be assembled by use of the process described in "Wafer-Level Membrane-Transfer Process for Fabricating MEMS" (NPO-21088), *NASA Tech Briefs*, Vol. 27, No. 1 (January 2003), page 58.



The **Silicon Actuator Membrane** would serve partly as an electrode that could be deformed by electrostatic attraction to the electrodes on the base. The deformation would be transferred to the mirror membrane.

The center-to-center distance of adjacent pixels could be as small as about 100 μm. A typical design would call for a center-to-center distance of 200 μm and a maximum deflection of about 2 μm. Calculations for a representative example of such a design, in which the actuator in one pixel generated a force of 10^{-4} N, yielded an estimated actuator-membrane deflection of 0.03 μm and mirror-membrane deflection of 0.4 μm. The adjacent-pixel influence coefficient in this example was found to be less than 10 percent.

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