

Modifications of Fabrication of Vibratory Microgyroscopes

The goal is to increase production yields.

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A micromachining process for the fabrication of vibratory microgyroscopes from silicon wafers, and aspects of the microgyroscope design that are inextricably linked with the fabrication process, have been modified in an effort to increase production yields from perspectives of both quantity and quality.

Prior to the modifications, the effective production yield of working microgyroscopes was limited to one or less per wafer. The modifications are part of a continuing effort to improve the design and increase production yields to more than 30 working microgyroscopes per wafer.

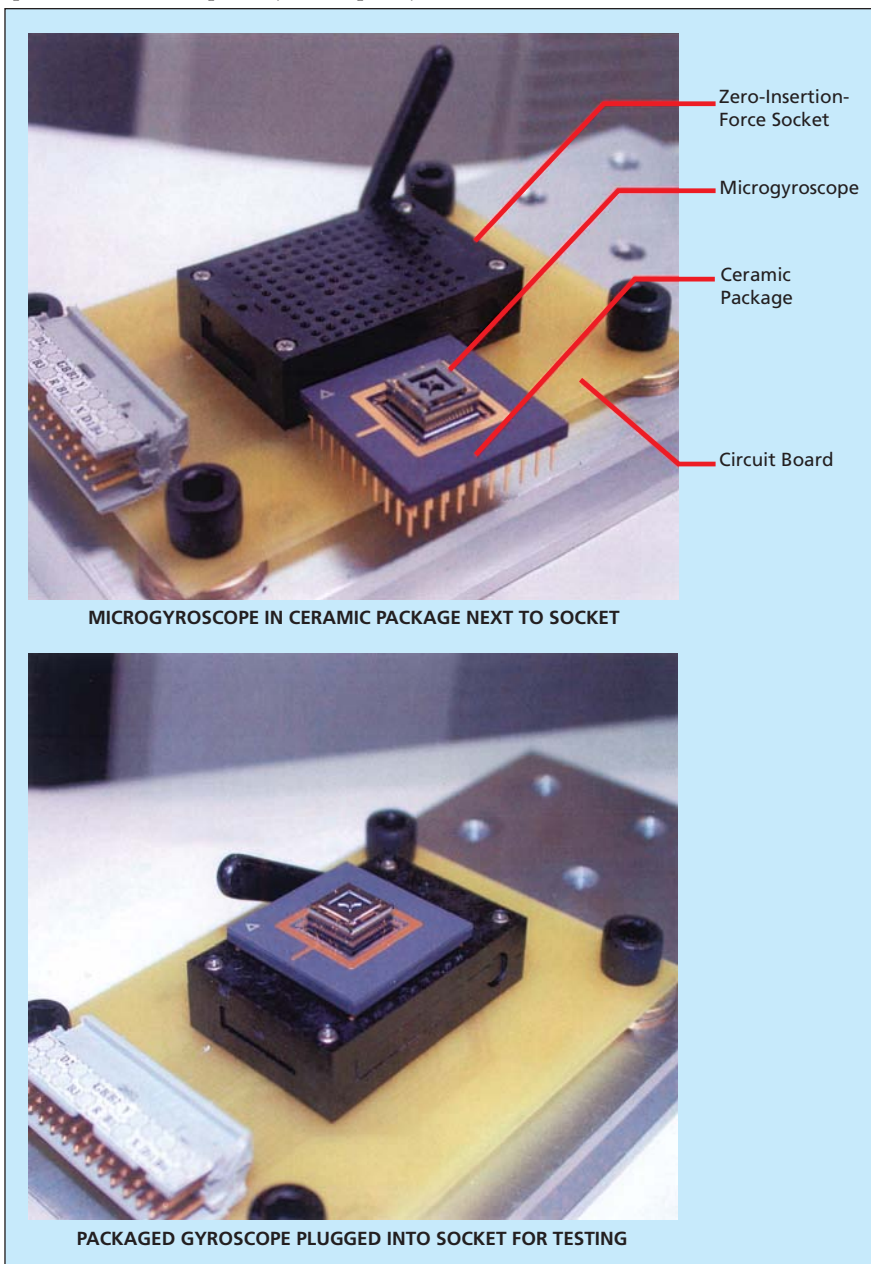
A discussion of pertinent aspects of the unmodified design and the unmodified fabrication process is prerequisite to a meaningful description of the modifications. The design of the microgyroscope package was not conducive to high yield and rapid testing of many microgyroscopes. One of the major impediments to high yield and testing was found to lie in vibration-isolation beams around the four edges of each microgyroscope, which beams were found to be unnecessary for achieving high resonance quality factors (Q values) characterizing the vibrations of petallike cantilevers.

The fabrication process included an 8- μm -deep plasma etch. The purpose of the etch was to create 8- μm vertical gaps, below which were to be placed large gold evaporated electrodes and sensing pads to drive and sense resonant vibrations of the "petals." The process also included a step in which bridges between dies were cut to separate the dies.

The etched areas must be kept clean and smooth (free of debris and spikes), because any object close to 8 μm high in those areas would stop the vibrations. However, it was found that after the etch, there remained some spikes with heights that were, variously, almost as high or as high as the etch depth. It also was found that the cutting of bridges created silicon debris, some of which lodged in the 8- μm gaps and some of which landed on top of the petals. The masses added to the petals by the debris altered resonance frequencies and/or Q values to unacceptable degrees. Hence, the spikes and the debris have been conjectured to cause most of the observed malfunctions of newly fabricated microgyroscopes.

Another pertinent aspect of the unmodified design and process was the fabrication of electrodes and the 8- μm capacitance gap on a 500- μm -thick wafer, and the fabrication of a 3-mm-thick baseplate from another wafer. It was necessary to bond these wafers to each other in an assembly step that was later found to be superfluous in that it could be eliminated by a suitable modification of the design.

The modifications include a redesign



A Plug-and-Test Design enables the testing of many microgyroscopes in a short time.

of the microgyroscope package to eliminate the vibration-isolation beams while providing acceptably high Q values ($\approx 4 \times 10^4$). The modified design includes a plug-in feature for quick testing (see figure). The plasma etch has been replaced by a wet etch, using a specially formulated KOH-based solution, that does not leave spikes. The design of the bridges has been modified to incorporate double notches, such that they can be cut without producing much debris, and a special suction tool resembling one used by a dentist has been developed to collect flying debris during cutting.

The superfluous assembly step has been eliminated by modifying the de-

sign so that all the functional parts previously fabricated on the 500- μm and 3-mm wafers are now fabricated entirely on 3-mm baseplate wafers only. In a previous approach to elimination of the superfluous step, KOH etches were made through 3-mm wafers, then metal patterns were formed by evaporating metals while using shadow masks (not standard practice). In the modified process, the metals are evaporated first (standard practice), then holes are ground by use of a diamond-tipped drill on an index table.

This work was done by Sam Y. Bae, Karl Y. Yee, and Dean Wiberg of Caltech for NASA's Jet Propulsion Laboratory. Fur-

ther information is contained in a TSP (see page 1).

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