MULTI-WAFER BULK MICROMACHINED NANO-g ACCELEROMETER

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Abstract

Ultrasensitive accelerometers, capable of measuring accelerations of the order of 10-8 g (1 0ng) are needed for the characterization of microgravity environment, measurement of orbital drag, and active aiming and isolation systems. Applications include science experiments on the space shuttle and space station, inertial navigation of spacecraft with ion propulsion, and aiming systems with microradian accuracies, NASA also has interest in measuring microseismic events on the earth, the moon and other planets.

The paper describes a multi-wafer bulk micromachined nano-g accelerometer that satisfies NASA microgravity experiments' requirements. Fully assembled accelerometers consist ing of four separate dies have been fabricated and tested.

The accelerometer utilizes an innovative approach to proof mass suspension and force actuation. The device employs a flexure suspension with a low axial spring constant: the device optimized for the bandwidth of up to 30 to 100117, has less than 10Hz open loop resonance frequency. The flexure is designed to minimize the cross-axis sensitivity. The flexure is not used to compensate for residual gravity; the compensation is performed by the actuation force. Compared to the conventional design, the low axial spring constant reduces by up to four orders of magnitude the thermal sensitivity, and the influence of the sensor noise on the accuracy of the accelerometer.

The accelerometer employs a dual electrostatic platen force feedback control circuit for mass movement. This circuitry controls all four modes of operation: parking, transition to active operation (capacitance control), operation (tunneling tip control), and overload protection. One of the advantages of the active control approach is its ability to measure acceleration over a very wide bandwidth. Current design is optimized for measurements in the frequency range from 0.0001 Hz to 30 Hz (compare to the open loop resonance frequency of 10} Iz). Lower accuracy measurements can be performed for frequencies up to 400l Iz.

The accelerometer uses a tunneling tip sensor as a position sensor. To protect the tunneling tip, we have employed a unique electrostatic clamping mechanism (patent pending).

'l'he paper discusses fabrication of the accelerometer and tile preliminary test results in all four modes of operation (parking, capacitance controlled transition, tunneling control, and protection modes).

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