Micromachined Gyroscopes with Two Degrees of Freedom Sense-Mode Oscillator

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BRIEF DESCRIPTION

The invention relates to the field of micromachined gyroscopes, and in particular to inertial micromachined transducers for measurement of angular rotation rate of an object.

A three-degrees of freedom (DOF) MEMS inertial micromachined gyroscope with nonresonant actuation with a drive direction, sense direction and a direction perpendicular to the drive and sense directions comprises a planar substrate, a 2-DOF sense-mode oscillator coupled to the substrate operated at a flattened wide-bandwidth frequency region, and a 1-DOF drive mode oscillator coupled operated at resonance in the flattened wide-bandwidth frequency region to achieve large drive-mode amplitudes.

FULL DESCRIPTION

The illustrated embodiment of the invention show a robust micromachined gyroscope with a two degrees-of-freedom (DOF) sense mode oscillator, which gyroscope addresses two major MEMS gyroscope design challenges: (1) the requirement of precisely matching drive and sense resonance modes, and (2) inherent instability and drift due to mechanical coupling between the drive and sense modes. The device measures angular rate of an object with respect to the axis normal to the substrate plane (the z-axis).

One of the major differences of the illustrated embodiment of the invention from prior art micromachined gyroscopes is that the sense-mode oscillator is a two-DOF dynamical system comprised of two interconnected proof-masses. The two-DOF sense-mode oscillator provides a frequency response with two resonant peaks and a flat region between the peaks, instead of a single resonance peak as in conventional gyroscopes. The device is nominally operated in the flat region of the sense-mode response curve, where the gain is less sensitive to parameter fluctuations.

Furthermore, the sensitivity is improved by utilizing dynamical amplification of oscillations in the two-DOF sense-mode oscillator. To eliminate the limitations of the existing micromachined gyroscopes including high sensitivity to variations in system parameters and narrow bandwidth, complexity of the control electronics can be shifted to complexity in the dynamical system. Thus, increased bandwidth and reduced sensitivity to structural and thermal parameter fluctuations and damping changes are achieved, leading to improved robustness and long-term stability over the operating time of the device. Prototype gyroscopes were fabricated using a bulk-micromachining process, and were successfully operated in the flat region of the sense-mode.

The performance and robustness of the device have been experimentally evaluated. With a 25V DC bias and 3V AC drive signal resulting in 5.8 μm drive-mode amplitude, the gyroscope exhibited a measured noise-floor of 0.640/s/pHz over 50 Hz bandwidth in atmospheric pressure. The sense-mode response in the flat operating region was also experimentally demonstrated to be inherently insensitive to pressure, temperature and DC bias variations.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	7,284,430	10/23/2007	2005-199

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CATEGORIZED AS

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