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Improving the PZT piezoelectric resonant sensors through finite-element simulation

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Miniaturized piezoelectric resonators of sizes 50 × 50, 100 × 100, 250 × 250, and 400 × 400 μm2 with 600-nm thickness have been made on silicon substrates. These sensors take sandwich structure with gold as the upper layer, platinum/titanium as the bottom layer, and PZT (lead zirconate titanate) as the middle layer. The sensor has been extensively characterized in terms of surface morphology, atomic composition, crystalline structure, leakage current, ferroelectric tunability, etc. The impedance spectroscopy shows good resonant characteristics. It is found that the size and aspect ratio of the sensor may have significant effects on the resonant property and sensing ability. This research uses the finite-element method (FEM) to direct further improvement of the PZT resonator. Displacement, stress, strain, and oscillation modes of the PZT chip will all be simulated with FEM. The electrical impedance of the sensor simulated with harmonic analysis is compared with that measured by an impedance analyzer. Sinusoidal waves of various frequencies are applied across the upper and bottom layers and the change in the shape of the PZT layer is observed. The frequency at which a PZT has the maximum deformation is recorded as the resonant frequency, which ranged from several MHz to several hundred MHz in our simulation. From the simulation results, the resonant frequency is found to decrease with increased PZT area, which conforms to piezoelectric theory. The improvement in the sensitivity of the resonant chip is aimed for sensitive microbalance measurement of bio-molecules, such as microalbumin from the urine.

Biography

Jang-Zern Tsai is an assistant professor of electrical engineering in National Central University, Jung-Li City, Taiwan. He received the BS degree in electrical engineering from National Central University, Taiwan, the MS degree in electrical engineering from National Tsing Hua University, Taiwan, and the PhD degree in electrical engineering from the University of Wisconsin-Madison, Wisconsin, USA. His current research interests include biochip design, biomedical instrumentation, biomedical signal processing, and bio-optics.

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