Self-Calibrating Micro-Fabricated Resonant Load Cells

Tech ID: 22701 / UC Case 2012-618-0

BRIEF DESCRIPTION

The technology is a cost-efficient and highly sensitive micro-mechanical test frames for the characterization of small-scale materials and structures. It is designed for a manufacturing process and self-calibration procedure for the practical use of MEMS resonant sensors as ultra-sensitive load cells. The properties of the technology include:cost-effective fabrication and implementation, load cells with unprecedented combinations of resolution and range, the ability for load cells to be mounted on hybrid micro-mechanical test frames or integrated with on-chip actuators, and the calibration involves no external instrumentation.

FULL DESCRIPTION

This invention consists of a manufacturing process and a self-calibration procedure for the practical use of MEMS resonant sensors as ultra-sensitive load cells. The process enables the cost-effective fabrication and implementation of load cells with unprecedented combinations of resolution and range. The sensor has been experimentally demonstrated a resolution of 7nN and a force range of 85mN, with a measured dynamic range of 144dB.

The device is a hybrid test frame, where the force sensor and displacement actuator are physically separated. The sensor element of the device is composed of a double ended tuning fork (DETF) resonator connected to a roller structure, where external load is applied. The roller structure is designed to transmit only the axial component of applied forces, thereby increasing the robustness of the sensor. A phase lock loop (PLL) circuit drives the sensor at resonance and adjusts the driving frequency based on detected changes in the natural frequency of the resonator that occur due to external forces. The MEMS sensing element is manufactured using a silicon on glass process and the sensor and readout circuit are fully embedded into a custom printed circuit board (PCB). The PCB is mounted onto a microstage and coupled with a commercial displacement actuator.

The sensor can be calibrated at different temperatures, with no external instruments. Calibration involves a simple g-test prior to use, where the sensor is rotated about its out-of-plane axis and the natural frequency of the tuning fork is measured. This method of calibration is simple and low cost and expands the application of the sensor for use in different temperature applications.

Such load cells can be mounted on hybrid micro-mechanical test frames or integrated with suitable on-chip actuators for the characterization of materials and structures at small scales.

With the recent development of micro-architectured cellular materials, new experimental techniques are needed for their mechanical characterization. Extremely sensitive, small scale micro-mechanical test frames with nN and nm resolution and wide force and displacement ranges are needed to provide accurate characterization of such materials. The ideal device should be capable of measuring forces with resolutions in the 1-100nN range with potentially large displacements (~1mm), allow optical (or SEM) access to the test coupon with potential for strain mapping (via Digital Image Correlation), be readily reconfigurable and adaptable to microstructures of a variety of shapes and sizes. This is a difficult problem and much of the currently available technology for micro-mechanical testing is costly and/or does not meet the aforementioned range, resolution, and versatility standards.

SUGGESTED USES

CONTACT

Alvin Viray
aviray@uci.edu
tel: 949-824-3104.

INVENTORS

- Azgin, Kivanc
- Valdevit, Lorenzo

OTHER INFORMATION

KEYWORDS

Force/Stress/Acceleration sensors, Calibration technique (s), Load cell

CATEGORIZED AS

- **Computer**
  - Software
- **Engineering**
  - Engineering
  - Robotics and Automation
- **Nanotechnology**

» Characterization of small-scale materials and structures

ADVANTAGES

- » Enables on site calibration of the load cell at any operating temperature, over the entire force range, and without requiring expensive external devices
- » The manufacturing process enables dramatically increased yield and reliability
- » Cost efficient and highly sensitive load cell

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	9,228,916	01/05/2016	2012-618

PUBLICATIONS

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LEAD INVENTOR

Lorenzo Valdevit
Associate Professor, Mechanical and Aerospace Engineering
Associate Professor (Joint Appointment), Chemical Engineering and Materials Science
Henry Samueli School of Engineering
University of California, Irvine
https://www.eng.uci.edu/users/lorenzo-valdevit http://valdevit.eng.uci.edu/

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