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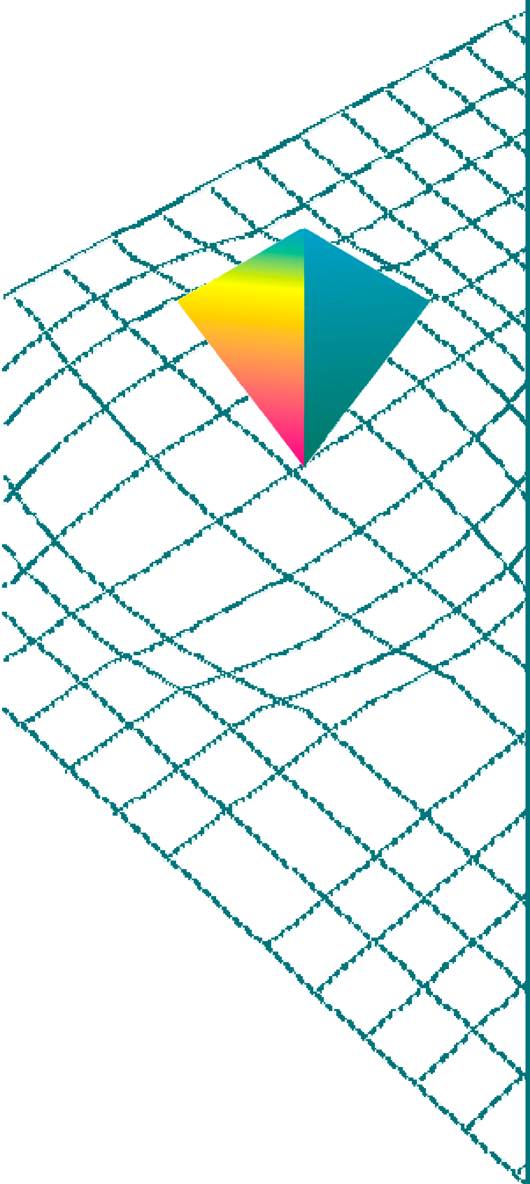

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50. Internationales Wissenschaftliches Kolloquium
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Micro-motion Analyzer to Study Dynamic Behavior of MEMS

ABSTRACT

A key purpose for testing microelectromechanical systems (MEMS) is to provide data feedback of measurements to the design and simulation in the process of development. A computer-controlled micro-motion analyzer (MMA) to study the dynamic behavior of movable structures of MEMS is described in this paper. It employs two optical methods: computer microvision for in-plane motion measurement and phase-shifting interferometry for out-of-plane motion measurement. This fully integrated system includes a high performance imaging system, drive electronics, data acquisition, and data analysis software. It can freeze the fast motions of MEMS devices using strobed illumination and measure motions in 3-dimensions at frequencies from 1 Hz to 10 MHz with nanometer resolution. The capabilities of this system are illustrated with a study of the dynamic behavior of a polysilicon lateral micro-resonator.

INTRODUCTION

The design and fabrication of MEMS need powerful measuring tools to enable their performance consistent with the designers' intent, and provide data feedback to the process of design and fabrication in the engineering development [1]. A computer-controlled micro-motion analyzer (MMA) to study the dynamic behavior of movable structures of MEMS is described in this paper. It employs two optical methods: computer microvision for in-plane motion measurement and phase-shifting interferometry for out-of-plane motion measurement [2, 3]. The capabilities of this system are illustrated with a study of the dynamic behavior of a surface micromachined polysilicon lateral micro-resonator.

SYSTEM SET-UP

The MMA is a highly integrated video microscope, using stroboscopic techniques to capture images of small, fast moving targets. The MMA uses both bright field and interference based illumination modes combined with sophisticated machine vision algorithms to quantify target motions. The MMA server and optics head combine the video microscopy with interferometry (Fig.1). There are two types of light sources: one is LED for in-plane motion measurement, and the other is LD for out-of-plane motion measurement. This fully integrated system includes a high performance imaging system, drive

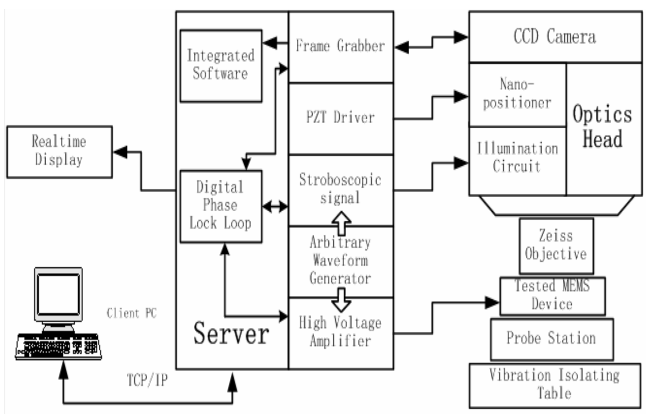
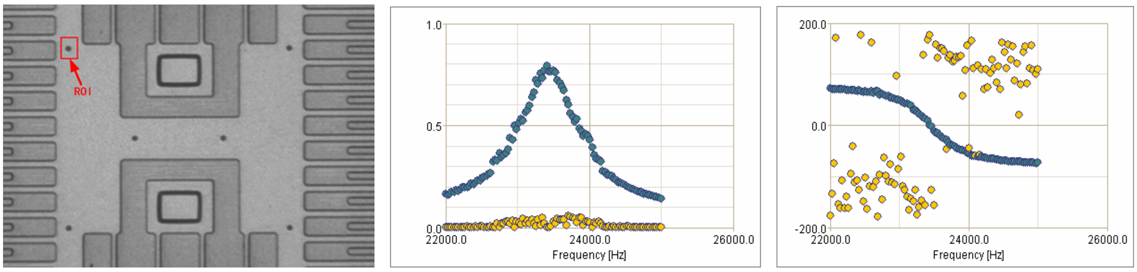


Fig.1 Scheme of the MMA

electronics, data acquisition, and data analysis software. A powerful report generator provides highly detailed information in a format ideal for MEMS researchers. This system can measure motions in 3-dimensions at frequencies from 1 Hz to 10 MHz with nanometer resolution. The measurement process is controlled by a client PC via local network with TCP/IP protocol.

EXPERIMENTAL RESULTS

In order to illustrate the capabilities of the system, we have measured the in-plane motions of a micro-resonator [4]. The stimulating waveform is sinusoidal signal with 10v amplitude and 20v offset. The illuminating source is LED. The range of sweeping frequency is from 22 kHz to 25 kHz. Eight phases are captured in one cycle measurement. One hundred times of frequency spaces will be measured. From the curves in Fig.2, the device can be fitted into a second-order system, and the resonator frequency of the device can be found. It is about 23.41 kHz, so the quality factor can be calculated, Q=23.41/(24.04-22.87)=20. The maximum moving amplitude in ROI is about 794.96 nm. Because of the air damp during the movement, the quality factor is not very large. All these data can be provided to the designers of MEMS, the quality factor of the device can be increased by improving the design of the micro-resonator's structure.



(a) Bright field image (b) Amplitude-frequency curve (c) Phase-frequency curve

Fig.2 In-plane sweeping frequency measurement of a lateral micro-resonator

CONCLUSION

The MMA is an optical, image based, metrology tool that provides nanometer scale dynamic profilometry and motion measurements of microstructures in three dimensions. It can measure fast motions below 10 MHz. The two key features make it to do rapid analysis of dynamic characterization of MEMS motions: 1) obtaining two dimensional data on samples without scanning; 2) computer-controlled automatic data acquisition.

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