MEMS Surface Characterization Based on White Light Phase Shifting Interferometry

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Abstract

This paper describes a new peak detecting algorithm combined carré phase shifting interferometry and white light interferometry. The new method can carry the fast, accurate and non-contact measurements. The testing system employs a Mirau objective on a piezoelectric transducer (PZT) based on a Zeiss microscope. Several numerical simulations are firstly carried to analyze its phase calculation errors due to the visibility variation in the white light interferogram. Afterwards, the centre of gravity method is adopted to concentrate the phase extraction on the zero-order fringe, which not only decreases the phase error, but also frees the data processing from the phase unwrapping procedure. The capabilities of the system and the proposed algorithm are evaluated through the measurements of a micro resonator and a 10μm standard step height.

1 Introduction

White light interferometry is a very powerful, widely used method in MEMS mapping technologies and arouses the worldwide interests to further improve its measurement capabilities[1-2].

2 System setup

The experimental setup integrates a Mirau objective on a Zeiss Axioplan 2 imaging microscope[3]. The Mirau objective is drived by a high precision piezoelectric transducer (PZT) to perform the vertical scanning. A CCD camera is also equipped to capture and transfer the images into the PC for data processing. The entire system is located on an air vibration isolation table, as shown in figure 1.

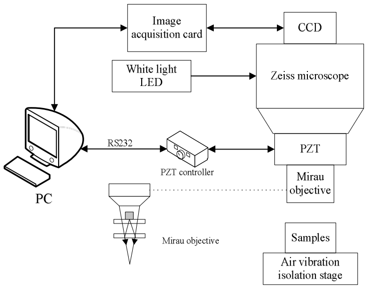


Figure 1: Schematic of the system setup

3 White light phase shifting interferometry

Unlike the monochromatic interferometry, white light interferogram's visibility is no longer a constant (in general case, a Gaussian function). When we employ the carré method to carry out the phase computation in a white light interferogram, error occurs. In the next subsections, we will use computer simulation to analyze how this kind of error will affect the measuring accuracy.

3.1 Phase computation simulation

As shown in figure 2, the error owing to the visibility variation around the coherence peak position is less than 0.02 rad in phase, or less than $\lambda/500$ in height, where λ is the wavelength of the light source. It is relatively much smaller than the errors came from the environment disturbance.

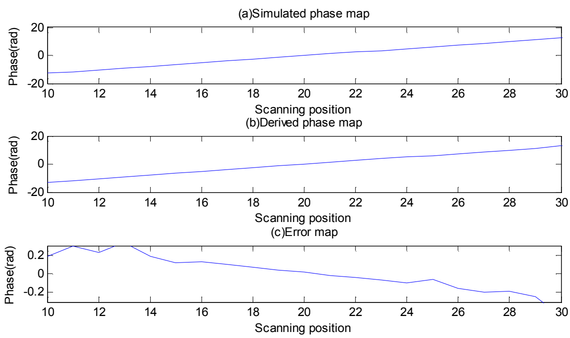


Figure 2: Phase extraction simulation (a) Simulated phase map (b) Derived phase map (c) Error map

3.2 Height computation simulation

Based on the phase computation simulation, the relative height of the tested profile h can then be written as:

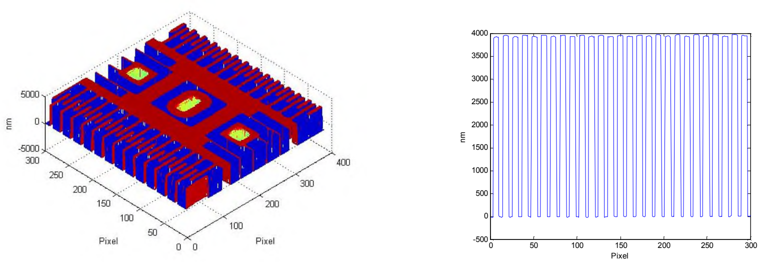
$$h = (stepnumber - peakstep) * \Delta - t * [\frac{(\varphi + 2k\pi)}{4\pi}\lambda] \quad (1)$$

Where *stepnumber* is the total scan number, *peakstep* corresponds to the phase term φ which comes out of carré method, Δ is the scan step length and t is the N.A. parameter from Ingelstam's equation[4]. The height of the simulation is set to be 1219.4nm and the processing result is 1220.6nm.

During the measurement, we used the centre of gravity method to focus the phase extraction on the zero-order fringe. Hence, k in equation (1) can be set to 0, which means the phase unwrapping is no longer needed.

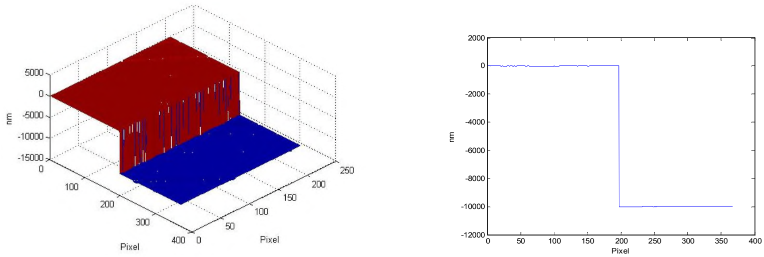
4 Experiments

In this section, we make a series of experiments to evaluate the capacity of the new method. A resonator and a 10μm standard step height(9.976μm ± 0.028μm,VLSI) are tested, as shown in figure 3 and figure 4.



(a) 3D structure of the resonator (b)Comb-finger profile of the resonator

Figure 3: Measurement of the resonator



(a) 3D structure of the 10µm standard step height (b) Profile of the 10µm standard step height

Figure 4: Measurement of the 10µm standard step height

4 Conclusions

In this paper, a new white light interferometry based on carré phase shifting technology is proposed, which combines the intensity with the phase information to locate the peak position of the interferogram. The capacity of the method is illustrated by several measurements within nanometer resolution.

References:

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