MULTIWAVELENGTH MICROSCOPY AS INSPECTION METHOD FOR PRINTED CIRCUIT BOARDS

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ABSTRACT

Digital holographic microscopy is a powerful 3D imaging tool for industrial surface inspection and scientific experiment evaluation. It provides similar lateral resolution as classical microscope and very fine axial resolution. This paper presents the device construction as well as experimental findings. The cornerstone of this research is multiwavelength holography combined with phase shifting with acousto-optic modulators.

INTRODUCTION

Microscopy is a standard inspection method for surface quality evaluation. One of the disadvantages of the classical microscopy is the ability to sense only light intensity. This drawback can be overcome by using digital holographic microscopy (DHM). DHM bestows microscope ability to precisely measure surface height. In combination with a high lateral resolution of the microscopes, it forms superior measurement device.

INTRODUCTION

Standard holographic measurement approach uses phase shifting to solve the problem of the unknown light intensity offset and gain. A few methods can be used to introduce phase shifting to the system. Our experimental microscope setup uses the set of the two fiber acusto-optics modulators in the reference and the signal arm in order to introduce phase shift between the two arms. AOMs can also be used to switch off one arm completely. Thus our device can be used as standard optical microscope.

EXPERIMENTAL SETUP

Our holographic microscope in Fig. 1 uses epi-Illumination so it is intended to be used to inspect opaque samples. The device is equipped with microscope objective (5×) and a linear actuator to position sample to the focus.

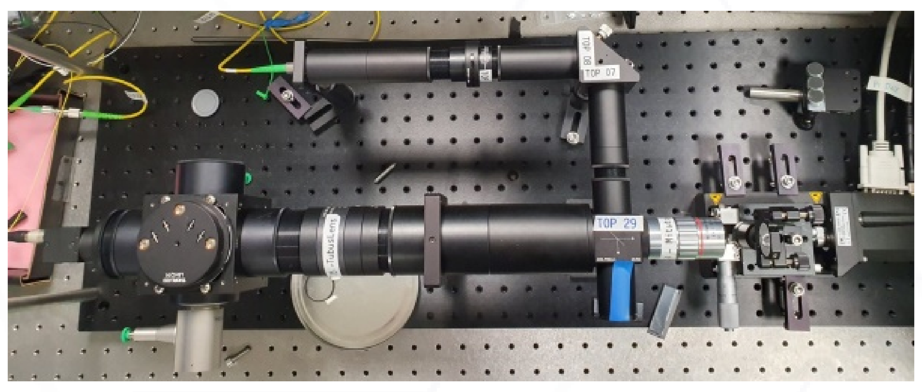

Figure 1: Experimental device

Two wavelength interferometry is based on measuring data at two known wavelengths. A tunable laser Toptica with wavelength range from 629 nm to 636 nm was used to provide two stable wavelengths for increased axial range.

MEASUREMENT PROCEDURE

A measurement procedure has multiple steps. For each wavelength phase shifting is performed using the acusto-optics modulators and multiple frames are acquired from the camera. In order to overcome various reflectivity of the surface, multiple shots with deiiferent expusures are taken (HDR bracketing).

The captured frames are evaluated by iterative least-squares phase-shifting to obtain phase for each wavelength. [1] A phase data from multiple wavelengths are then evaluated in order to get the synthetic phase and the surface shape.

EXPERIMENTAL DATA

This measurement method can be used for example for a printed circuit board (PCB) inspection when a production technology needs to be optimised. It can provide information about the height and the shape of each surface layer.

$$\lambda_s = \frac{\lambda_2 \cdot \lambda_1}{|\lambda_2 - \lambda_1|} \qquad (1)$$

A presented experimental data was measured at two different wavelengths 631 nm and 632 nm. Based on equation (1), it means that synthetic wavelength was 398 μm. [2]

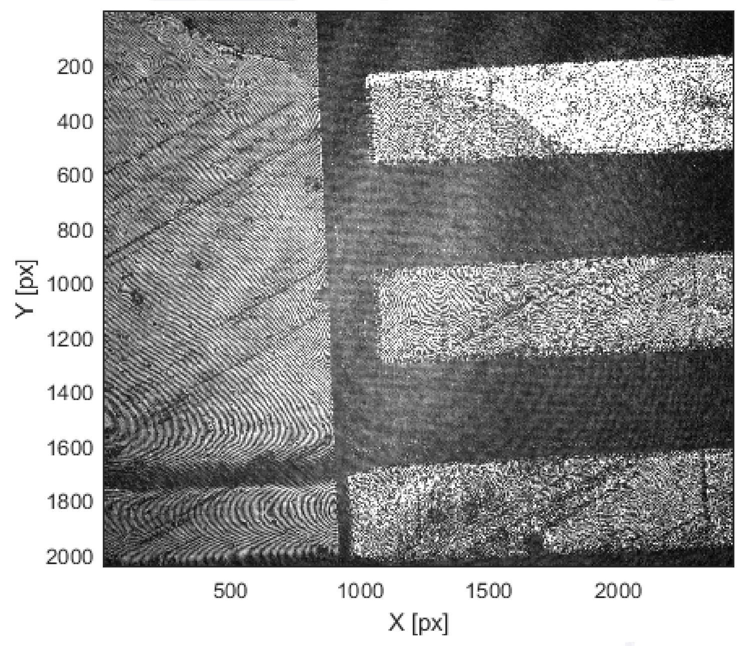

Figure 2: Intensity image of part of the sample PCB

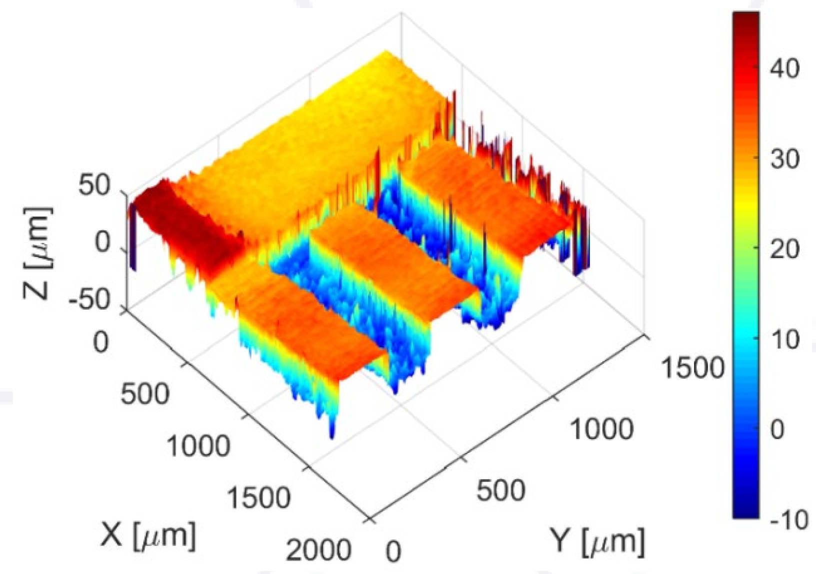

Figure 3: Evaluated height data of the sample PCB

The used piece of the PCB is challenging sample as mostly dark surface is partially covered with highly reflective metal layers. Thanks to the dynamic range enhancing technique, it was possible to measure a whole visible area.

The phase and the OPD was evaluated from a multiple consecutive intensity images as presented in Fig. 2. General algorithm of phase-shifting interferometry by iterative least-squares fitting was used to obtain phase data from the intensity images. [1]

It is clearly visible in Fig. 3 how fine the lateral and the height resolution of measurement method is.

CONCLUSIONS

The assembled experimental device and the performed experiment helped to verify the theoretical principles of the DHM. The measurement procedure enhancement to increase dynamic range was devised and tested. The measured data were used to test and develop the data evaluation algorithms. It was proven that the acusto-optics modulators are relatively stable and can be used as the reliable source of the metrological grade phase shifting.

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