Dual Moiré and Laser Interferometry as a Metrology Tool

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INTRODUCTION

Measurement of physical parameters of a large object or scene accompanies by losing detailed information about small regions of object. In fact techniques developed to make measurement in large scale (macro) are very different from those measuring at small scale (micro). This problem is one of the challenges in the field of surface metrology.

One optical method that is used for surface metrology at macro scale is Moiré technique [1]-[4]. Laser interferometry is another metrology method which has been used for measuring fine features [5]. There is no reported work that combines the large scale measurement of Moiré techniques with high accuracy of laser interferometer.

This article addresses this challenge. The work presented in this article combines these two techniques allowing detailed surface texture of a small region of a very large object to be analyzed while the overall form and shape of the object is measured. The challenge here is stitch data from Moiré system and laser interferometer. Authors proposed a method [6] based on image registration to accomplish stitching.

SYSTEM DESIGN AND SIMULATION

Figure 1 shows the schematic of proposed system. For Moiré measurement, projection moiré technique is used. The laser interferometer is a Michelson interferometer that is placed close to object and in front of optical elements. This choice of location of laser interferometer makes sure that the laser wavefront almost only deformed by the object and not optical elements before interfering with reference beam of the laser. Figure 2 shows the implemented system.

To evaluate the system, both projection Moiré and laser interferometer of the system were simulated in MATLAB™ environment. Laser
FIGURE 3. Simulated object and the resultant interferogram from Moiré projection and laser interferometer at different levels of zoom.

interferometer was modeled as

\[ I(r, t) = I_0[1 + V\cos(\delta(r))]R_s(r) + R_E(r, t) \]

where \( V \) is fringe contrast, \( \delta(r) \) is phase that corresponds to profile of the object, \( R_s(r) \) is speckle noise and \( R_E(r, t) \) is electronics noise. Moiré simulation was performed using ray-tracing technique.

Figure 3 shows the simulated object at different zoom levels and the corresponding simulated interferograms for both projection Moiré and laser interferometer.

EXPERIMENT

Interferograms from a surface with solder bumps were acquired at different levels of zoom. Figure 4 shows the acquired interferograms and the final stitched image.

Table 1 shows the uncertainty analysis that was performed to characterize the system.

REFERENCES


TABLE 1. Error percentage at different zoom levels for projection Moiré and laser interferometer

<table>
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<th>Zoom Level</th>
<th>Projection Moiré Normalized Error</th>
<th>Laser Interferometer Normalized Error</th>
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