Shape measurement of lateral moving objects using Linear Digital Holography

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Digital holography (DH) is an advanced technology used in a wide range of fields, including medicine and biology, and has attracted attention in the field of industrial measurement as one of its applications. In particular, its non-contact nature, micro-order accuracy, and real-time performance make it an extremely suitable technology for line inspection in factories. In recent years, as semiconductor microfabrication technology has become more sophisticated, high accuracy is required for the inspection of semiconductor components to ensure product performance and reliability. Against this backdrop, the demand for high-throughput optical shape measurement technology is becoming increasingly important as chipletization continues to advance.

DH is considered an ideal technology for the inspection of semiconductor components because of its high speed of image measurement and its ability to achieve sub-wavelength vertical resolution. This technology consists of three processes: recording, development, and playback. Holograms are recorded by using laser light to generate interference fringes between an object light and a reference light. Then, based on the recorded holograms, shape information can be obtained with sub-wavelength accuracy through the reproduction process.

However, the conventional DH uses 2D images as input, and the large number of measurement points results in an enormous amount of computation, making it particularly challenging to meet the high-speed requirements of factory production lines. To address this problem, we propose a new method called "Linear Digital Holography (LDH)," which uses one-dimensional images as input, as an alternative to conventional DH. By using one-dimensional line images, this method reduces unnecessary point measurements, resulting in a significant reduction of measurement points and data volume. As a result, the calculation speed is improved, and the system can respond to the speed of quality inspections on production lines.

The optical system of the LDH uses a Michelson interferometer and assumes an environment where the object to be measured moves at a constant speed on a conveyor. First, one-dimensional interference fringe data is acquired using an image sensor, which is Fourier transformed in the computer to obtain a spectrum. Then, the primary light is extracted, and the amplitude and phase information is recovered by inverse Fourier transform. By repeating this series of processes, highly accurate shape information can finally be obtained. In this study, the practicality and accuracy of LDH were verified through computer simulations and optical experiments.

Short biography:

Yuma Sato was born in 2001 in Iwate Prefecture, Japan, he grew up in Iwate Prefecture until the age of 18. He graduated from Iwate Prefectural Mizusawa High School in March 2020 and entered the Faculty of Engineering at Utsunomiya University in April of the same year. he entered the graduate school of Utsunomiya University in April 2024. He is a member of the Hayasaki Laboratory at the Center for Optical Education and Research (CORE), Utsunomiya University, where his research field is digital holography.