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Lateral movement and angular illuminating non-uniformity corrected TSOM image using Fourier transform

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Abstract: Through-focus scanning optical microscopy (TSOM) is a high-efficient, low-costed, and nondestructive model-based optical nanoscale method with the capability of measuring semiconductor targets from nanometer to micrometer level. However, some instability issues resulted from lateral movement of the target and angular illuminating non-uniformity during the collection of through-focus (TF) images restrict TSOM's potential applications so that considerable efforts are needed to align optical elements before the collection and correct the experimental TSOM image before differentiating the experimental TSOM image from simulated TSOM image. An improved corrected TSOM method using Fourier transform is herein presented in this paper. First, a series of experimental TF images are collected through scanning the objective of the optical microscopy, and the ideally simulated TF images are obtained by a full-vector formulation. Then, each experimental image is aligned to its corresponding simulated counterpart before constructing the TSOM image. Based on the analysis of precision and repeatability, this method demonstrates its capability to improve the performance of TSOM, and the promising possibilities in application of online and in-machine measurements.

1. Introduction

Through-focus scanning optical microscopy (TSOM) is a model-based optical metrology method [1] which has been proved promising in such areas of the semiconductor and nanotechnology industry as i) mask defect inspection [2], ii) three-dimensional (3D) measurement for Fin field-effect transistors (FinFET), high aspect ratio(HAR) features, and other structures based on 22 nm nodes [3–5], and iii) determination of nanoparticle sizes [6], with advantages of high-efficiency and low-cost [7]. A 2D image called the TSOM image comes from a series of through-focus (TF) images and is key to the TSOM method. 3D geometric information of the target is indirectly extracted by matching the experimental TSOM image to the simulated TSOM image; therefore, it is highly sensitive to interruptions during TF images collection, such as the mechanical noise of lateral movements of the target and the optical noise of angular asymmetry of Kohler illumination [8]. The mechanical and optical noise is proved to decrease the measurement accuracy and limits the range of potential applications of the TSOM method, such as those pertaining to online and in-machine conditions [9–12].

Some attempts have been expended on such noise. As for lateral vibrations, often in subpixel

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