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Measuring uncertainty for various types of dual-rotating-compensator spectroscopic ellipsometers

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Various multichannel rotating-element spectroscopic ellipsometers have excellent measurement capabilities, such as real-time, high-precision, non-destructive and non-contact, resulting in widespread use in semiconductor manufacturing processes. With the development of semiconductor device processing technology, thin films used in these techniques have become thinner and thinner, reaching the atomic layer level, and the shape of the nano-pattern has changed from a two-dimensional structure to a three-dimensional structure. It is becoming more and more complicated. Therefore, to continue to use the rotating-element spectroscopic ellipsometer as a measurement tool in the next-generation semiconductor industry, it is important to continually increase measurement uncertainty. Recently we have developed a universal evaluations and expressions of measuring uncertainty for all types of rotating-element spectroscopic ellipsometers [1]. We also introduced a general data-reduction process to demonstrate the universal analytical function of the combined standard uncertainty of the ellipsometric sample parameters. To solve the incompleteness of the analytic expressions, we formulate the estimated covariance for the Fourier coefficient means extracted from the radiant flux waveform using a new Fourier analysis [2]. Our approach provides a method for calculating theoretical model equations that can be applied to various kinds of multi-channel rotating-element spectroscopic ellipsometers and can determine the theoretical equations for the measured confidence level, i.e. combined standard uncertainty of ellipsometric sample parameter. In this presentation it is shown that the calculation data of the combined standard uncertainty for various types of rotating element spectroscopic ellipsometer is obtained using a universal representation of the combined standard uncertainty. In particular, the calculation results for the dual-rotating-compensator spectroscopic ellipsometers will be compared and evaluated with the calculated results for the common single-rotating spectroscopic ellipsometers.
[1] Y. J. Cho, W. Chegal, J. P. Lee, and H. M. Cho, Opt. Express **24**, 26215 (2016).
[2] Y. J. Cho, W. Chegal, J. P. Lee, and H. M. Cho, Opt. Express **23**, 16481 (2015).

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