Special Section Guest Editorial: Manufacturing Data Analytics

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Manufacturing data analytics is one of the pillars of the lithography and photomask industries. Our industry is driven by ongoing improvements in patterning, metrology, and inspection, which in turn rely on the enabling tools of modeling, simulation, and optimization. An acceleration of the time to impact from data insights is critical to enhancements in manufacturing quality and yield, increased equipment productivity, reductions in manufacturing costs, and a quickening of the mass availability of new products. Modern fabs generate terabytes of manufacturing control data per day. While there is less product development data, it tends to be less structured and more complicated to use. Both sets of problems are important, challenging, and require the deployment of advanced data analytics solutions, which are applications of a wide range of techniques. This special section of JM^3 features five exemplary papers which advance different aspects of data analytics related to process optimization, metrology and inspection, and process and optical proximity correction (OPC) simulations.

Two papers in the collection treat process optimization problems pertaining to self-aligned patterning processes and have different approaches and emphases. Zhang et al. explore the use of backscattered electron imaging to find and control fin cut damage in a FinFET double-patterning process through a classical linear analysis of the variability of critical dimension, overlay, and pitch walking. Halle et al. advance process control by proposing the machine learning technique of Bayesian dropout approximation to analyze pitch-walk values for some processing steps of self-aligned quadruple patterning and to offer estimates of the uncertainty of predictions to assist with decision making. In both articles, the authors address the challenge of limited availability of data.

By contrast, large volumes of data are continually produced in wafer fabs. Image data used to be particularly difficult to handle. However, the advent of deep learning techniques has facilitated the automation of image analysis problems such as image classification. Le-Gratiet et al. showcase five use cases in a high volume manufacturing environment where convolutional neural network solutions are being applied by means of the enabling technique of transfer learning.

The remaining two papers advance the state of the art in simulation through deep learning. Tanabe and Takahashi consider how to efficiently generate training data to use deep learning to approximate rigorous electromagnetic simulations in a mask area. They predict mask diffraction spectra and propose a data augmentation approach which markedly reduces the data preparation time and enhances the network accuracy. Ciou et al. present a proof-of-concept of a pixelated machine-learning based OPC framework in which a generative adversarial network uses mask data from an earlier generation together with wafer data to reproduce an OPC flow for a new mask tapeout that satisfies after development inspection criteria.

We thank the authors for papers that highlight the significance and breadth of manufacturing data analytics. We are also grateful to the reviewers for their time and their detailed and insightful feedback on these articles. Early in our preparations we received valuable input from JM^3 Associate Editors Linyong (Leo) Pang and Alexander Starikov. This special section came about because of a panel we co-organized for the 2021 European Mask and Lithography Conference. One of our panelists was JM^3 Editor-in-Chief Harry Levinson, who invited us to prepare this special section. We would not have this collection of scholarly contributions without his encouragement and advice as well as the support of the SPIE editorial staff. We hope you will take interest in these papers.