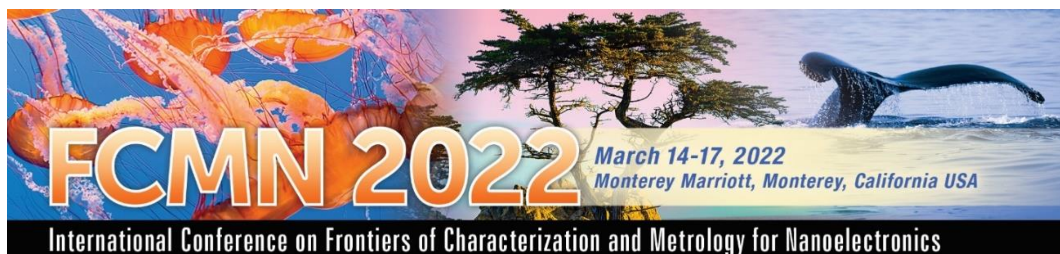

Tutorial 1A: Machine Learning for Metrology

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Metrologists in semiconductor manufacturing often operate at the leading edge of measurement science, supported by breakthroughs in various scientific and engineering disciplines. Computational advances enabled by this metrology have fostered wide-spread applications of machine learning, with presently is forming a virtuous cycle as ML is increasingly implemented in process control. This tutorial presents key ML concepts to foster an improved understanding of ML capabilities for industrial metrology. The tutorial surveys key algorithmic tools and known applications in semiconductor manufacturing. Special focus will be placed not only upon deep learning (e.g., convolutional neural networks) but also upon Gaussian processes and Bayesian optimization. These focus areas will be tied to patterned defect and critical dimension metrologies.

Bryan M. Barnes is a Physicist in the Advanced Electronics Group of the Nanoscale Device Characterization Division at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD, USA. His research career centers on deep-subwavelength light scattering and its applications for dimensional metrology, especially in support of the semiconductor industry. These interests have motivated an ongoing project, “Quantitative Nanoscale Imaging Through Artificial Intelligence,” which focuses on rigorous applications of machine learning (ML) to two metrology challenges. The project is pursuing ML approaches to better address the cost sensitivity inherent to patterned defect inspection and to augment optics-based approaches for determining sub-wavelength parametric dimensions and their uncertainties. Dr. Barnes serves as Co-Chair of the SEMI Standards North America Microlithography chapter, as a Program Committee member of the “Metrology, Inspection, and Process Control” conference at SPIE Advanced Lithography & Patterning, and a Co-chair of the “Modeling Aspects in Optical Metrology” conference at SPIE Optical Metrology. He has been awarded a 2016 U.S. Department of Commerce Silver Medal “for pioneering advances in optics, imaging structures 30 times smaller than the wavelength of light with near atomic accuracy” (with colleague Dr. Richard M. Silver). He has also been recognized as a co-Principal Developer of “Quantitative Hybrid Metrology,” earning a 2013 R&D 100 Award from the editors of R&D Magazine. He has authored over 20 peer-reviewed publications and over 40 conference proceedings. He received a B.A. in Mathematics and Physics from Vanderbilt University and a M.S. and Ph.D. from the University of Wisconsin-Madison.

Ali Mesbah is an Associate Professor of Chemical and Biomolecular Engineering at the University of California at Berkeley. Before joining UC Berkeley, Dr. Mesbah was a Senior Postdoctoral Associate at MIT. He holds a Ph.D. degree in Systems and Control from Delft University of Technology. Dr. Mesbah is a Senior Member of the IEEE and AIChE. He serves on the IEEE Control Systems Society Conference Editorial Board and IEEE Control Systems Society Technology Conference Editorial Board, and is a subject Editor of Optimal Control Applications and Methods and IEEE Transactions on Radiation and Plasma Medical Sciences. Dr. Mesbah is a recipient of the Best Application Paper Award of the IFAC World Congress in 2020, the AIChE's 35 Under 35 Award in 2017, the IEEE Control Systems Outstanding Paper Award in 2017, and the AIChE CAST W. David Smith, Jr. Publication Award in 2015. His research interests lie at the intersection of optimal control, machine learning, and applied mathematics, with applications to learning-based analysis, diagnosis, and predictive control of materials processing and manufacturing systems.