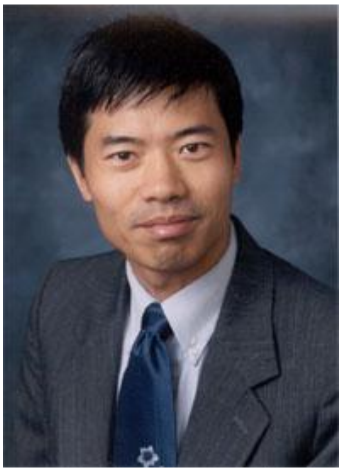
Keynote Speech (I)

Data-based Scheduling of Semiconductor Manufacturing Fabrication Facility



Mengchu Zhou
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PROF. MENGCHU ZHOU received his B.S. degree in Control Engineering from Nanjing University of Science and Technology, Nanjing, China in 1983, M.S. degree in Automatic Control from Beijing Institute of Technology, Beijing, China in 1986, and Ph. D. degree in Computer and Systems Engineering from Rensselaer Polytechnic Institute, Troy, NY in 1990. He joined New Jersey Institute of Technology (NJIT), Newark, NJ in 1990, and is a Distinguished Professor of Electrical and Computer Engineering and the Director of Discrete-Event Systems Laboratory. He is presently also a Professor at the MoE Key Laboratory of Embedded System and Service Computing, Tongji University, Shanghai, China. His research interests are in intelligent automation, Petri nets, sensor networks, semiconductor manufacturing, Web service, and big data. He has over 520 publications including 11 books, 260+ journal papers (majority in IEEE transactions), and 22 book-chapters. Dr. Zhou is the founding Editor of IEEE Press Book Series on Systems Science and Engineering. He is Associate Editor of IEEE Transactions on Systems, Man and Cybernetics: Systems, IEEE Transactions on Industrial Informatics and IEEE Transactions on Intelligent Transportation Systems. He served as Guest-Editor for many journals including IEEE Transactions on Industrial Electronics and IEEE Transactions on Semiconductor Manufacturing. He was General Chair of 2008 IEEE Conf. on Automation Science and Engineering, 2003 IEEE International Conference on System, Man and Cybernetics (SMC), and 2006 IEEE Int. Conf. on Networking, Sensing and Control. He was Program Chair of 2010 IEEE International Conference on Mechatronics and Automation and 2001 IEEE International Conference on SMC and 1997 IEEE International Conference on Emerging Technologies and Factory Automation. Dr. Zhou has led or participated in 50 research and education projects with total budget over $12M, funded by NSF, DoD, NIST, and industry. He was the recipient of NSF's Research Initiation Award, CIM University-LEAD Award by Society of Manufacturing Engineers, Perlis Research Award and Fenster Innovation in Engineering Education Award by NJIT, Humboldt Research Award for US Senior Scientists, Leadership Award and Academic Achievement Award by Chinese Association for Science and Technology-USA, and Outstanding Contributions Award, Distinguished Lecturership and Franklin V. Taylor Memorial Award of IEEE SMC Society, and Distinguished Service Award from IEEE Robotics and Automation Society. He was founding Chair of Semiconductor Manufacturing Automation Technical Committee of IEEE Robotics and Automation Society. He is founding Co-chair of Enterprise Information Systems TC and Environmental Sensing, Networking, and Decision-making TC of IEEE SMC Society. He is a life member of Chinese Association for Science and Technology-USA and served as its President in 1999. He is Fellow of IEEE, IFAC and American Association for the Advancement of Science (AAAS).

***Abstract*—**Semiconductor wafer fabrication facility (fab) is one of the most complex manufacturing processes. Based on the analysis on the difficulties to schedule wafer fabs, we propose a data-based scheduling framework to meet their scheduling requirements in a fast and high-quality way. It has three main parts, including a simulation environment, scheduling rules and learning machines. The simulation environment is built by means of modularization and decoupling the algorithms from the models, including model modules, release control modules and scheduling modules. Totally, there are two modeling modules, three release control modules and nine scheduling modules. The simulation environment is used to generate plentiful samples under different scenarios. The scheduling rules include a release control strategy and dispatching rule, responsible for making release and dispatching decisions, respectively. A learning machine is used to train the parameters of the release control strategy and dispatching rule to be adaptive to dynamic production environments. Two cases based on a real 6-inch fab are used to validate and verify the superiorities of the proposed method. The simulation results show that the proposed method is superior to common release control strategies and dispatching rules in terms of productivity.

Keynote Speech (II)

Models for the Throughput of Clustered Photolithography Tools with Applications

James R. Morrison
KAIST, South Korea

DR. JAMES R. MORRISON received the B.S. in Mathematics and the B.S. in Electrical Engineering from the University of Maryland at College Park, USA. He received the M.S. and Ph.D. in Electrical and Computer Engineering from the University of Illinois at Urbana-Champaign, USA.

From 2000 to 2005, he was with the Fab Operations Engineering Department, IBM Corporation, Burlington, VT, USA. He is currently an Associate Professor in the Department of Industrial and Systems Engineering at KAIST, South Korea. His research interests focus on semiconductor wafer manufacturing, persistent UAV service, education as a service and eco-design. He has published over 70 peer reviewed journal and conference papers in these areas. He received the KAIST Award for Excellent Teaching and the KAIST Creative Teaching (Grand Prize) Award in 2011 and 2012, respectively. In 2013, he received the KAIST Excellence in International Cooperation Award. His Ph.D. students' papers were best student paper finalists at IEEE CASE 2012 and 2013. His paper was awarded the Grand Prize in the academic thesis category at the Korean DAPA International Military Science and Technology Fair in July 2013.

He has served as a Guest Editor for the IEEE Transactions on Automation Science & Engineering and Computers & Operations Research. He served on the Organizing Committee for the 2012, 2013 and 2014 IEEE Conference on Automation Science and Engineering (IEEE CASE), the 2013 and 2014 International Conference on Unmanned Aircraft Systems (ICUAS) and the 2014 Conference on Modeling and Analysis of Semiconductor Manufacturing (MASM). Since January 2009, he has been a Co-Chair of the IEEE Robotics and Automation Society Technical Committee on Semiconductor Manufacturing Automation.

***Abstract*—**The clustered photolithography tool (CPT) is the most expensive piece of equipment in a semiconductor wafer fabricator. Modern state-of-the-art CPTs can cost as much as US$ 100 million. In this talk, we discuss a variety of models that can be used to describe the wafer throughput rate, lot residency time and lot queueing time of a CPT. We focus on flow line models and simpler models derived from flow lines. When compared with data from CPTs in operation, these models can provide throughput predictions within 1% of the actual values. However, they are orders of magnitude less computationally complex than detailed simulation models. We discuss application opportunities for such models including CPT throughput optimization, lot residency time reduction (which improves sector agility) and use in fabricator optimization, simulation and planning engines.

Tutorial Talk (I)

Post FAB Complexity – Litho is not the End of the Known World

Kenneth Fordyce (IBM retired), Director of Analytics, Arkieva, USA

DR. KEN FORDYCE is currently the director of Analytics and Semiconductor solutions for Arkieva. Previously he worked for IBM from 1977 until his retirement at the end of 2013 in all aspects of planning, scheduling, and dispatch especially for the production of semiconductor based packaged goods. He had the good fortune to part of the CPE team which developed and deployed the Central Planning Engine for IBM Micro-electronics Division and Analog Devices and the LMS team which developed and deployed one of the first real-time dispatch scheduling systems for FABs. Additionally, Ken has the opportunity to often collaborate with an outstanding set of co-authors and editors on a range of publications from FAB capacity to micro-satellite instability and colon cancer. Dr. Fordyce can be reached at kfordyce@arkieva.com and 914/388-0321.

***Abstract*—**The purpose of any demand supply network is to meet prioritized demand on time without violating constraints and as much as possible meet business policies (inventory, preferred suppliers, request and commit date, etc.). Typically, the demand supply network for the production of semiconductor based packaged goods (SBPG) is divided into FAB and POST-FAB. The dynamic interaction between the two is limited in nature for logical and historical reasons. One reason is the nature of complexity which makes life interesting for planners is different between FAB and POST-FAB. FAB has long routes, reentrant flow, deployment and the ever present shadow of the operating curve – to name a few – generating wafer start / cycle time focus. POST-FAB is faced with constant exit demand uncertainty, allocation of shared components and capacity to competing demands, alternative operations; transport decisions, and the all-important "plan repair" – name a few – generating an exit demand / efficiency frontier focus. Their differences become clear when examining the nature of the models (from spreadsheets to optimization) supporting decisions and analysis.

The purpose of this presentation and companion write-up is to provide an overview of the POST FAB complexity. To accomplish we will focus on feature and functions found in Central Planning models or engines that support the end to end planning for the production of SBPG which historically have been POST FAB focused.

Tutorial Talk (II)

Interpolation Approximations for Queues in Series

Kan Wu
Nanyang Technological University, Singapore

DR. KAN WU is an assistant professor in the Division of Systems and Engineering Management at Nanyang Technological University. He received the B.S. degree from National Tsinghua University, M.S. degree from University of California at Berkeley, and Ph.D. degree in Industrial and Systems Engineering from Georgia Institute of Technology. He has ten years experience in the semiconductor industry, from consultants to managers. Before joining NTU, he was the CTO and founding team member of a startup company in the US. His PhD dissertation was awarded the 3rd place for the IIE Pritsker Doctoral Dissertation Award in 2010. His research interests are primarily in the areas of queueing theory, with applications in the performance evaluation of supply chains and manufacturing systems.

***Abstract*—**Exact queue times of tandem queues are difficult to compute in general. We propose a new approximation approach, based on observed properties of the behavior of tandem queues, which we call the intrinsic gap and intrinsic ratio. The approach exploits what we call the nearly-linear and heavy-traffic properties of the intrinsic ratio, which appear to hold in realistic production situations. Across a broad range of examined cases, this new approach outperforms earlier approximation methods.

Tutorial Talk (III)

Simulation-based Performance Assessment of Production Planning and Scheduling Approaches in Complex Manufacturing Systems

Lars Mönch
University of Hagen, Germany

LARS MÖNCH is professor of Computer Science at the Department of Mathematics and Computer Science, University of Hagen where he heads the Chair of Enterprise-wide Software Systems. He holds MS and Ph.D. degrees in Mathematics from the University of Göttingen, Germany. After his Ph.D., he obtained a habilitation degree in Information Systems from Technical University of Ilmenau, Germany. His research and teaching interests are in information systems for production and logistics, simulation, scheduling, and production planning. He has published over 45 journal articles and over 100 conference papers. He is an Associate Editor of European Journal of Industrial Engineering and of Business & Information Systems Engineering. His research was supported by the German National Science Foundation (DFG), the German Government, the European Commission, SEMATECH, and several semiconductor manufacturers including Infineon Technologies AG, GLOBALFOUNDRIES, and X-FAB Semiconductor Foundries AG. He can be reached by email at lars.moench@fernuni-hagen.de.

***Abstract*—**We start by presenting briefly the main ideas of a general framework for manufacturing systems based on ideas from system theory. Each manufacturing system consists of a base system and an information system. Corresponding processes are distinguished. The information system can be further decomposed into a planning system, a control system, and an operational system. We demonstrate how discrete-event simulation can be used to emulate the base system and the related base process.

In the second part of the tutorial, we discuss a scheme that can be used to carry out a simulation-based performance assessment of production planning and scheduling approaches which are applied in a rolling horizon setting. Related performance measures including stability measures are presented. In addition, we present some details of a simulation environment that can be used to conduct the performance assessment.

In the third part of the tutorial, we apply the sketched simulation-based framework in two different situations. As a first example, we discuss the simulation-based performance assessment of the shifting bottleneck heuristic applied to scheduling lots in a wafer fab in a rolling horizon setting. The performance measure is the total weighted tardiness of the lots. Computational results are presented that demonstrate that the shifting bottleneck heuristic outperforms due date-oriented dispatching rules. The second example deals with the simulation-based assessment of production planning approaches for semiconductor manufacturing in a static and a rolling horizon setting, respectively. Again, simulation results are presented. We outline the differences between the first example that is more operational and the second example that is more tactical.

We discuss briefly future research efforts related to simulation-based performance assessment schemes in the final part of the tutorial. New challenges arise from increasing the level of detail in the base system, for instance, by considering automated material handling systems or cluster tools and by taking into account large-scale supply chains in the semiconductor industry.

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