ISMI 2014

International Symposium on Semiconductor Manufacturing Intelligence

Enabling A+ Decisions®

August 16 - 18, 2014

Palais de Chine Hotel, Taipei, Taiwan

Program and Abstract Book

Organized by:

科技部IC產業同盟計畫

STEP Consortium

Semiconductor Technologies Empowerment Partners Consortium

清華-台積電 卓越製造中心

NTHU-TSMC Center for Manufacturing Excellence

中華卓越經營決策學會

Society for Excelling Enterprises and Decisions

Sponsored by

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Ministry of Education
Department of Information and Tourism, Taipei City Government
Taiwan Semiconductor Industry Association (TSIA)
Chinese Institute of Industrial Engineers (CIIE)
Asia Pacific Industrial Engineering & Management Society (APIEMS)

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Welcome Message

Welcome to Taipei, Taiwan. It is our great privilege to hold the 2014 International Symposium on Semiconductor Manufacturing Intelligence (ISMI2014). This event is co-organized by Semiconductor Technologies Empowerment Partners (STEP) Consortium, Society for Excelling Enterprises and Decisions (SEED) and NTHU-TSMC Center for Manufacturing Excellence.

The objective of the ISMI2014 aims to provide a platform to foster the exchange of research developments and latest practice on automation science & engineering, evolutionary algorithms, data mining and big data analytics, manufacturing informatics, modeling and decision analysis, and operation management for semiconductor and high-tech manufacturing to enhance collaborations among academia and industries. Furthermore, the involved research and applications are not limited to conventional manufacturing domains and can be extended to manufacturing-based services as well as emerging areas such as green supply chains, logistics, and business analysis and optimization (BAO).

This event is co-sponsored by the Ministry of Science and Technology, Ministry of Education, Department of Information and Tourism, Taipei City Government, Taiwan Semiconductor Industry Association (TSIA), Chinese Institute of Industrial Engineers (CIIE), Asia Pacific Industrial Engineering & Management Society (APIEMS). We would like to thank distinguished keynote speakers including Professor Mengchu Zhou of New Jersey Institute of Technology from USA, Professor James R. Morrison of the Korean Advanced Institute of Science and Technology from South Korean, Dr. Kenneth Fordyce (IBM retried) of the Arkieva from USA, Professor Kan Wu of Nanyang Technological University from Singapore, Professor Lars Mönch of University of Hagen from Germany. We also form a Student Paper Award to encourage junior researchers to more focus on Manufacturing Intelligence related topics. This year, we selected 5 papers with high potential into finalist based on Student Paper Award Committee's review.

Special thanks are given to Delta Electronics, Inc., a world leading world's leading electronic company for their supports of on-site visiting and field study. Finally, we would like to thank all of the participants and organizers for their contributions in this successful joint event in Taipei, Taiwan.

Chen-Fu Chien, Ph.D.
ISMI2014 General Chair
Director, NTHU-TSMC Center for Manufacturing Excellence
Tsinghua Chair Professor, National Tsing Hua University

Jei-Zheng Wu, Ph.D.
ISMI2014 Program Committee Chair
President, Society for Excelling Enterprises and Decisions (SEED)
Soochow University

August 16th - 18th, 2014

TAIPEI

Taipei City Government

Lung-Bin Hau, Ph.D.
Mayor

Office of the Mayor
Taipei, Taiwan, Republic of China

臺北市市長 郝龍斌

Honoured Guests

Welcome to Taipei! On behalf of the Taipei City Government and the city's 2.68 million inhabitants, I would like to extend our warmest welcome to all participants in the 2014 International Symposium on Semiconductor Manufacturing Intelligence.

I'd like to express our deep appreciation towards the Society for Excelling Enterprises and Decisions for their commitment to ensuring the success of this global gathering. This event will provide a constructive conduit for the exchange of knowledge and expertise in semiconductors, and promises to be a rewarding experience for all involved.

On a different note, be sure to take time out to explore our exhilarating city. Apart from Taipei 101, an awe-inspiring skyscraper, you can also visit the much-vaunted National Palace Museum, which houses some of the world's most important historical artifacts, and make use of the celebrated Taipei Metro, perhaps the world's best rapid transit system. Taipei has many well-kept secrets awaiting your discovery. Nestling in the mountains are a number of well-made, eco-friendly hiking trails for the fitness-minded. If day-tripping gives you sore feet, world-class hot springs await your call in the northern suburbs. Taipei has also made great strides in protecting wildlife and rehabilitating wild areas—stop by the Guandu Nature Park and you will be amazed by its rich biodiversity. Be adventurous and check out the quaint cafés, retro teahouses and boutique art galleries. The quiet alleys that crisscross Taipei are full of little treasures!

As host city and sponsor of the 2014 International Symposium on Semiconductor Manufacturing Intelligence, we hope you have a wonderful time and take home the most beautiful memories.

Sincerely yours

Lung-bin Hau

Lung-Bin Hau
Mayor of Taipei

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Schedule

Day 1:	**Saturday, 16 August**
15:30	**Registration** **(Voltaire, 5F)**
18:30	**Welcome Reception Dinner** **(Rousseau + Descartes + Voltaire + Pascal, 5F)**
Day 2:	**Sunday, 17 August**
08:30	**Registration** **(Grand Hall A, 5F)**
09:00	**Opening** **(Grand Hall A, 5F)**
09:00	Welcome Message by General Chair: Prof. Chen-Fu Chien, National Tsing Hua University, Taiwan
09:10	Keynote Speech Data-based Scheduling of Semiconductor Manufacturing Fabrication Facility *Professor Mengchu Zhou, New Jersey Institute of Technology, USA* Chair: Professor Jei-Zheng Wu, Soochow University, Taiwan
09:50	Break
10:10	Keynote Speech II Models for the Throughput of Clustered Photolithography Tools with Applications *Professor James R. Morrison, KAIST, South Korea* Chair: Dr. C. Hsu, Taiwan Semiconductor Manufacturing Company
10:50	Break
11:00	Student Paper Award Finalist Chair: Professor Chia-Yen Lee, National Cheng Kung University, Taiwan
12:00	**Lunch** **(Rousseau + Descartes, 5F)**
13:00	**Technical Sessions**
13:00	Tutorial Talk (Grand Hall A, 5F) (I) Post FAB Complexity – Litho is not the End of the Known World *Dr. Kenneth Fordyce (IBM retired), Director of Analytics, Arkieva, USA* (II) Interpolation Approximations for Queues in Series *Professor Kan Wu, Nanyang Technological University, Singapore* (III) Simulation-based Performance Assessment of Production Planning and Scheduling Approaches in Complex Manufacturing Systems *Professor Lars Mönch, University of Hagen, Germany* Parallel Session A: Scheduling & Dispatching (Pascal, 5F) Parallel Session B: Modeling & Decisions (Voltaire, 5F)
14:40	Break
14:50	Parallel Session C: Manufacturing Intelligence (Grand Hall A, 5F) Parallel Session D: Manufacturing Excellence (Pascal, 5F) Parallel Session E: Quality Engineering (Voltaire, 5F)
16:30	**Break**
18:30	**Banquet & Award Ceremony** **(Rousseau + Descartes + Voltaire + Pascal, 5F)**
Day 3:	**Monday, 18 August**
09:30	**Industrial Visit: Delta Electronics, Inc.**
11:30	**Transportation to Fullon Hotel at Tamsui Fishermen's Wharf (IEEE CASE2014)**

Program

August 16th (Saturday)

15:30 Registration (Voltaire, 5F)

18:00 Welcome Reception Dinner (Rousseau + Descartes + Voltaire + Pascal, 5F)

August 17th (Sunday)

08:30 – 09:00 Registration (Grand Hall A, 5F)

09:00 – 09:10 Opening (Grand Hall A, 5F)

Welcome Message by Tsing Hua Chair Professor Chen-Fu Chien, ISMI2014 General Chair

09:10 – 09:50 Keynote Speech (Grand Hall A, 5F)

Title: Data-based Scheduling of Semiconductor Manufacturing Fabrication Facility

Speaker: Professor Mengchu Zhou, New Jersey Institute of Technology, USA

Chair: Professor Jei-Zheng Wu, Soochow University, Taiwan

09:50 – 10:10 Coffee Break

10:10 – 10:50 Keynote Speech II (Grand Hall A, 5F)

Title: Models for the Throughput of Clustered Photolithography Tools with Applications

Speaker: Professor James R. Morrison, KAIST, South Korea

Chair: Dr. C. Hsu, Taiwan Semiconductor Manufacturing Company

10:50 – 11:00 Coffee Break

11:00 – 12:00 Student Paper Award Finalist (Grand Hall A, 5F)

Chair: Professor Chia-Yen Lee, National Cheng Kung University, Taiwan

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31 Simulation Verification for Layout Design – Is Shortest Distance Always Good?
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12:00 – 13:00 Lunch (Rousseau + Descartes, 5F)
13:00 – 16:30 Technical Sessions

13:00 – 14:40 Tutorial Talk (Grand Hall A, 5F)
Chair: Dr. Yi-Chun Chen, Taiwan Semiconductor Manufacturing Company, Taiwan

Talk I: Post FAB Complexity – Litho is not the End of the Known World
Speaker: Dr. Kenneth Fordyce (IBM retired), Director of Analytics, Arkieva, USA

Talk II: Interpolation Approximations for Queues in Series
Speaker: Professor Kan Wu, Nanyang Technological University, Singapore

Talk III: Simulation-based Performance Assessment of Production Planning and Scheduling Approaches in Complex Manufacturing Systems
Speaker: Professor Lars Mönch, University of Hagen, Germany

13:00 – 14:40 Session A (Pascal, 5F)
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Session Chair: Professor Juhong Gao, Tianjin University, China

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07 Decision-making and Coordination in Closed-loop Supply Chain Based on Greening Efforts
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Topic: Modeling & Decisions

Session Chair: Professor Shuguang He, Tianjin University, China

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24 A Three-level Sustainable and Resilient Supply Chain Network Design under Disruption
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14:50 – 16:30 Session C (Grand Hall A, 5F)

Topic: Manufacturing Intelligence

Session Chair: Professor Young Jae Jang, KAIST, South Korea

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04 Application of Critical-Siphon Theory to Fastest Deadlock Controller to Enhance the Intelligence of Semi-Conductor Flexible Manufacturing Systems
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Topic: Manufacturing Excellence

Session Chair: Professor Byung-Hyun Ha, Pusan National University, South Korea

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Topic: Quality Engineering

Session Chair: Professor Bin Nie, Tianjin University, China

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16:30 – 18:30 Break

18:30 Banquet & Award Ceremony (Rousseau + Descartes + Voltaire + Pascal, 5F)

August 18th (Monday)

09:30 – 11:30 Industrial Visit: Delta Electronics, Inc. (http://www.deltaww.com/)

Delta Electronics, Inc., founded by Mr. Bruce C.H. Cheng in 1971, is the world's largest provider of switching power supplies and DC brushless fans, as well as a major source for power management solutions, components, visual displays, industrial automation, networking products, and renewable energy solutions. And also known as an OEM for a number of brands in the home computing industry, the computer enthusiast sub-culture for PC components routinely comments upon Delta as a high quality brand in areas such as power supplies and cooling fans. Delta mission statement is to provide innovative, clean and energy-efficient solutions for a better tomorrow, thus, they focus their role in addressing key environmental issues such as global climate change, and continue to develop innovative energy efficient products and solutions.

In recent years they have transformed from a product provider toward a solution provider and their businesses now encompass power electronics, energy management, and smart green life. Delta's brand promise "Smarter, Greener, Together." encourages the development and broad application of smart, energy-efficient solutions. And they devoted to innovation and systematically developing new products and technologies, particularly those that are high efficiency and energy saving, and invests over 5% to 6% of their groups' annual sales revenue in R&D. They have worldwide R&D facilities in Taiwan, China, Thailand, Japan, the U.S., and Europe. Their national honors for innovation include the Taiwan National Industry Innovation Award (2008 and 2012) and the Thailand Prime Minister's Industry Award (1995, 2010, 2011, and 2012).

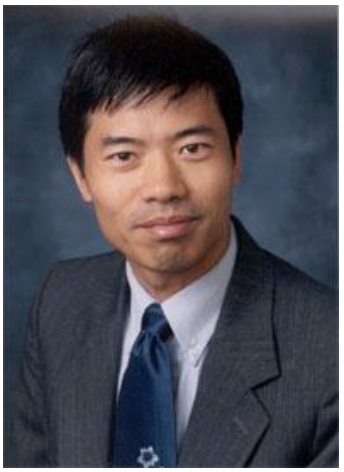
Throughout Delta Group's history they have received many global awards and recognition for their business, technology, and corporate social responsibility. In 2012 Delta was selected for two of the prestigious Dow Jones Sustainability Indexes — the DJSI World Index and the DJSI Asia/ Pacific Index—for the 2nd consecutive year. Delta was also ranked first among the 29 leading companies in the Electronic Equipment sector and named as "Sector Leader" for the first time. Since 2010, Delta has received 47 internationally recognized design awards including the iF, Reddot, CES Innovation, Computex Best Choice, and Taiwan Excellence awards.

Delta will continue its dedication to developing technologies and solutions that aim to reduce global warming and ensure mankind's sustainable future.

Keynote Speech

Keynote Speech (I)

Data-based Scheduling of Semiconductor Manufacturing Fabrication Facility



Mengchu Zhou
New Jersey Institute of Technology, USA

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

Tutorial Talk (I)

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

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.

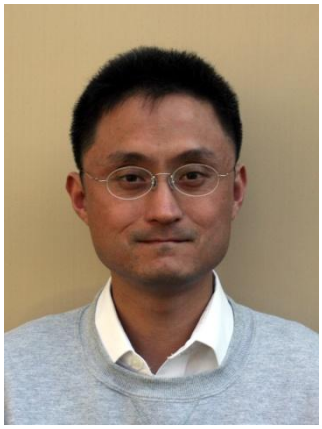
Kenneth Fordyce
(IBM retired), Director of Analytics, Arkieva, USA

***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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Technical Sessions

Student Paper Award Finalist — Aug. 17, 11:00 – 12:00 (Grand Hall A, 5F)

[S1-17] A Robust Technical Platform Planning Method to Assure Competitive Advantage under Uncertainties

Jr-Yi Chiou[1], Yi-Hsuan Lin[1], Ming-Chuan Chiu[1], and Wu-Hsun Chung[2]*

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***Abstract*—** Developing a technology-based product platform (technical platform) that can deliver a variety of products has emerged as a strategy for obtaining competitive advantage in the global marketplace. Technical platform planning can improve customer satisfaction by integrating diversified products and technologies. Prior studies have alluded to developing a robust framework of technical platforms and validated methodologies. We propose a multi-step approach to organize technical platforms based on corporate strength while incorporating technological improbability during platform development. A case study is presented to demonstrate its advantages, referencing a company developing 3-Dimension Integrated Circuitry (3D-IC) for the semiconductor industry. We evaluate four alternatives to ensure compliance with market demands. This study applies assessment attributes for technology, commercial benefits, industrial chain completeness, and risk. Using Simple Multi-Attribute Rating Technique Extended to Ranking (SMARTER), decision-makers can quickly determine efficient alternatives in uncertain situations. Finally, a scenario analysis is presented to simulate possible market situations and provide suggestions to the focal company. Results illustrate the proposed technical platform can enhance companies' core competencies.

Keywords: Technical platform planning; Decision analysis; Technology management; Fuzzy simple multi-attribute rating technique extended to ranking (SMARTER); 3-dimension integrated circuit (3D-IC).

[S2-31] Simulation Verification for Layout Design – Is Shortest Distance Always Good?

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***Abstract*—** The main objective of this paper is to identify the effect of the large amount of flows on automated material handling system (AMHS) performance when determining the number of OHT-vehicles in the semiconductor FAB for the AMHS. This research considers generation of a from/to matrix to estimate the lower bound of the number of OHT-vehicles using mathematical modeling. AMHS performance is simulated based on this number with heavy flows. The simulation results show that it is impossible to transport lots between bays because there is congestion on the AMHS track due to vehicle interference when a FAB layout is designed based on the minimum distance between tools or bays.

Keywords: Automated material handling system (AMHS); Semiconductor manufacturing fab; Vehicle fleet sizing; Vehicle interference; Congestion.

[S3-21] A Similarity Ranking Approach to Reduce False Alarm of Defect Classification in CMOS Image Sensor Manufacturing

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***Abstract*—** For CMOS image sensor (CIS) manufacturing, defect reduction is a key taskforce for quality assurance and yield enhancement. Indeed, automatic optical inspection (AOI) is the critical equipment for defect inspection. Although AOI can capture possible defect images with high throughput and low manual labor, it cannot identify the defect types for troubleshooting purpose. In particular, the advanced AOI equipment can provide a high resolution defect image of a whole wafer for overall judgments. This study aims to develop a hybrid data mining approach for defect clustering for whole wafer images based on the result of ADC system. The proposed approach consists of similarity comparison to rearrange the order of features from different images of CMOS. This concept could not only enhance the correct rate but reduce the false count rate. An empirical study was conducted in a leading CIS manufacturing company in Taiwan to estimate the validity and the results also demonstrated the practical value of the proposed approach.

Keywords: CMOS image sensor manufacturing; Yield enhancement; Clustering; Similarity ranking; Defect detection and classification.

[S4-18] A Prognostics and Health Management (PHM) Framework for Semiconductor Manufacturing Processes

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***Abstract*—** Because semiconductor industry is capital and technology-intensive, effective and accurate solutions for management of the fabrication (FAB) process is required. Hence, methodologies which monitor the process condition recognize a wafer defect and predict the wafers yield are employed to improve FAB process and wafer yield. This pa-per proposes a generic framework to manage the semiconductor FAB process. Through surveying related papers, PHM is recognized as the most suitable approach for our frame work. Moreover, because of a variety of semiconductor processes, an integrated data model is designed to aggregate and manage input and output data effectively. Therefore, a generic framework based on PHM is formed to improve semi-conductor manufacturing system.

Keywords: Semiconductor manufacturing; Prognostics and health management (PHM); Integrated management framework; Diagnosis; Predict.

[S5-29] A Web-based Capacity Planning System for a Semiconductor Wafer Fabrication: Design and Implementation

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***Abstract*—** Capacity planning plays a key role of operations management in semiconductor manufacturing. In this article, we study long-term strategy planning for investment decisions and mid-term resource allocation planning for capacity allocation decisions. Multi-objective optimization is considered for designing a computer planning system to address these decisions, and the system architecture of the web-based capacity planning is developed. This system design has been successfully implemented for a semiconductor wafer fabrication in China.

Keywords: Semiconductor manufacturing; Capacity planning; Multi-objective optimization; Analytic hierarchy process.

Session A: Scheduling & Dispatching — Aug. 17, 13:00 – 14:40 (Pascal, 5F)

[A1-34] Scheduling of Multi-purpose Machines using Simulation Techniques in a Hard Disk Drive Industry

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***Abstract*—** This article presents the research-based solutions of multi-purpose machine scheduling in the hard disk drive industry. Simulation of the production line was conducted using the Arena program. When a single machine has a capacity of simultaneous multi-functioning, there is a limitation with its robot arm, which loads and unloads work pieces. The problem is scheduling the hard drives input into the machine. The complication lies in the cooperation between the machine and the robot arm. This study developed an algorithm to find a range of initial solutions for loading the hard drives into the machine. The OptQuest function for Arena was applied in order to find the most appropriate solution with an objective to obtain the maximum values of machine and robot arm utilization. The solutions thus found were compared with scheduling models from other methods. The experiment showed that the developed method yields the machine utilization values equal to other methods. However, the value of robot arm utilizations was higher than other methods, yielding a higher output per time period.

Keywords: Simulation; Scheduling; Multi-purpose machines.

[A2-35] Parallel Machines Scheduling under Uncertain Conditions using Simulation Model in the Hard Disk Drive Industry

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[1] Department of Industrial Engineering, Nakhon Ratchasima Rajabhat University, Thailand.

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***Abstract*—** This article presents the result of research on the simulation of parallel machines scheduling under varying conditions in the hard disk drive industry. The Arena simulation program for unrelated parallel machines was used. The research problem was how to allocate numerous products to several unrelated parallel machines. Normally, all products are allocated to all parallel machines, resulting in less efficiency in production. This research developed an algorithm for scheduling operation of unrelated parallel machines and compared the efficiency by simulating manufacturing under variable production situations. Two simulation models of scheduling were designed with the total output, the average total time and the average work in process (WIP) as the indicators. The result shows that the algorithm for scheduling production on parallel machines was more efficient than conventional product scheduling at a significant level of 95%.

Keywords: Simulation; Heuristics algorithm; Scheduling; Unrelated parallel machines.

[A3-27] Genetic Algorithm for Multi-objective Flexible Job-shop Scheduling Problem under Uncertain Processing Time

Thitipong Jamrus[1], Chen-Fu Chien[1], Mitsuo Gen[2], and Kanchana Sethanan[3]*

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***Abstract*—**Flexible job-shop scheduling problem (FJSP) is a NP-hard problem with combinatorial complexity. To deal with this FJSP problem, a sequence of operations satisfying the precedence relationship will be generated together with job assignment of time and resources for each operation. Thus, the FJSP is more complex than job-shop scheduling problem (JSP) due to the need to determine the assignment of machines. On the other hand, the data in scheduling problem are fuzzy and the processing time is normally imprecise in practice Thus, existing approaches with constant processing time may not appropriate to address the FJSP. The combining of several optimization criteria induces additional complexity and new problems.

This study aims to propose a Genetic Algorithm (GA) with Adaptive Auto Tuning using Fuzzy Logic Controller (FLC) to solve the FJSP to find a job sequence that minimizes the uncertain makespan, the maximal machine workload and the total workload of machines. To estimate the validity of the proposed, an experiment was designed to compare the several scale problems. This study concludes with discussions of contributions and future research directions.

Keywords: Flexible job shop scheduling problem (FJSP); Fuzzy processing time; Multi-objective optimization; Genetic algorithm (GA).

[A4-07] Decision-making and Coordination in a Closed-loop Supply Chain Based on Greening Efforts

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***Abstract*—**Considering the positive influence of greening efforts on market demands, this paper aims to study the decision-making and coordination of a closed-loop supply chain (CLSC) where chain members exert efforts for the greening project. We build game theoretic models of the centralized and decentralized CLSC with one manufacturer and one retailer, to investigate the optimal pricing, greening effort decisions and profits of the CLSC. We further examine the efficiency of the cost sharing contract and the sales revenue sharing contract in coordinating the CLSC. The results show that the performance of the decentralized CLSC is lower than that of the centralized CLSC. The greening effort decisions and profits of the CLSC are always positively related to the demand expansion effectiveness of the greening effort. The cost sharing contract cannot coordinate a CLSC well, while the sales revenue sharing contract can enable the perfect coordination of the CLSC

Keywords: Closed-loop supply chain; Greening effort; Game theory; Cost sharing contract; Sales revenue sharing contract.

[A5-38] A New Priority to Computer Experimental System

Yu-Bin Lan[1], Shin-Chung Chuang[1], Chen-Fu Chien[1], and Jei-Zheng Wu[2]*

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***Abstract*—** As the rapid development of technology of semiconductor manufacturing, the IC designs have become increasingly complicated so that IC design processes have relied on heavy computer analysis that requires capital investment for computing resources. However, the computer resource is expensive and limited, and therefore it became a critical problem to well allocate the computer resource. This paper aims to purpose a new priority method to reduce engineers' waiting time and enhance dispatching system efficiency in dynamic and stochastic environment. Several indicators were defined to quantify the vague workload and service rate, and hence the user can get a good understanding on the situation of system and resource easily. The best one and its parameter setting would also derived from a series of simulation study. The empirical study conducted in IC design service corporation has validated the developed solution.

Keywords: Stochastic scheduling; Priority; IC design; Simulation experiment.

Session B: Modeling & Decisions — Aug. 17, 13:00 – 14:40 (Voltaire, 5F)

[B1-10] A Prescribed Probability Particle Swarm Optimization with Adjusting Random

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***Abstract*—** Particle swarm optimization (PSO) simulates social behavior such as birds flocking and fish schooling. It is an emerging population-based meta-heuristic and a population based evolutionary algorithm to achieve precise objectives in a multidimensional space. A population (called swarm) is made up of individuals (called particles) that are updated from iteration. Each particle accords its own best previous experience (pBest) and the best experience (gBest) of all other members to correct searching direction. Two important factors are pBest and gBest. Four advantages of PSO algorithm: few parameters to adjust, easy to understand, easy to implement and computationally efficient. But it easy to be trapped into local optima and the convergence rate decreased considerably in the later period of evolution processing. One of reasons falling into the local optimum early is used random value to Influence the weight of pBest and gBest. Our research proposed given a prescribed probability to adjust random, not only prevent the algorithm from falling into the local optimum early, but also improve convergence speed and search performance. Our method compared with the standard PSO algorithm based on 8 standard testing benchmark functions. The results show that convergence accurateness is faster for 6functions.

Keywords: Particle swarm optimization; Prescribed probability; Conditional random.

[B2-23] Grey-Goal Programming based approach for Managing Product Safety Risk in Supplier Selection Decision

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***Abstract*—** Large number of product recall scandals in global supply chain indicates that manufacturers and consumers are vulnerable to product quality and safety risks. Quality and safety of ingredients, components and packaging material are paramount to success of any manufacturer and it is extremely difficult to successfully maintain these attributes without considering a suitable set of suppliers. This paper proposed framework for reducing the product safety risks associated with suppliers. The proposed framework is based on three stages: (1) Identification of product safety issues associated with suppliers, (2) defining weights to goals and ratings to supplier attributes as a grey linguistic variable, and (3) supplier selection and order allocation using grey-goal programming. Grey system theory based approach is used to tackle the stochastic and recognitive uncertainties associated with supplier selection decision. The proposed model will help the practitioners to understand the importance of handling recognitive and stochastic uncertainties simultaneously and give practitioners an effective tool to evaluate and select a suitable set of suppliers and optimal order allocation to each selected supplier such that product safety risks should be minimized.

Keywords: Supplier evaluation; Supplier selection; Product safety; Grey systems theory; Grey programming.

[B3-24] A Three-level Sustainable and Resilient Supply Chain Network Design under Disruption

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***Abstract*—** Today supply chain management is emerging in a new dimension by having the sustainability as its primary focus, but in reality, however, facilities and the links connecting them, disrupt from time to time due to poor weather, natural or man-made disasters, or a combination of any other factors. Due to these unexpected disruptions, supply chain system drop its sustainability while coping with them. Now, the new challenges for the supply chain managers are to design an efficient and effective supply chain network that will be resilient enough to bounce back from any disruption and also should have sufficient vigilance to offer same sustainability under disruption state. Out of three pillars of sustainability namely ecological, social and economic sustainability, this paper is focusing more on the ecological sustainability because environmental focus in supply chain system is more important and also link with other pillars as the products need to be produced, packed and transported in an ethical way which should not harm social balance and environment. Owing to importance of the issue, this paper attempts to introduce network optimization model for sustainable and resilient supply chain network. The proposed goal programming (GP) model optimizes the total cost while considering the resilience and sustainability of the supply chain network.

Keywords: Resilient supply chain; Sustainable supply chain; Disruptions.

[B4-26] MECE Variable Selection: an Example of Semiconductor Manufacturing

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***Abstract*—**Semiconductor manufacturing process includes large number of variables and data usually contains unimportant, irrelevant and noise information. It's difficult to use the 'Big Data" for trouble-shooting or fault detection. This study proposes a mutually-exclusive-and-collectively-exhaustive (MECE) feature selection scheme to reduce process data dimension and to provide critical process variables [3] in semi-conductor manufacturing. We select the features by using three phases: measure of independence, measure of important, and measure of completeness. Finally, we validate MECE scheme using classification technique of good/bad product for improving variable selection and supporting yield improvement.

Keywords: MECE; Feature selection; Data mining; Semiconductor manufacturing; Stepwise selection.

[B5-16] An Application of Fuzzy Analytic Hierarchy Process in Evaluating Crisp Activity Relationship Chart based on the Lean Layout Concept

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***Abstract*—**The most significant objective of any manufacturing industries has been the maximum utilization of layout to achieve desired goal of productivity and profitability. The manufacturing layout problem is an unstructured decision-making problem due to natural vagueness associated with the inputs to the models. Thus, this study applies the fuzzy analytic hierarchy process in evaluating crisp activity relationship chart based on the lean layout concept. The input values associated with different linguistic variables used in the formulation of proposed fuzzy interference system are material flow, information flow, personnel flow, and transportation flow. Then, we calculate the criteria weights by applying Fuzzy Analytic Hierarchy Process: FAHP method. After that, the measurement of relationship ratings between departments in the plant layout corresponding to each criterion is conducted under the setting of fuzzy set theory and simulated an output relationship rating by using MATLAB software. The result indicated that the FAHP based on the lean layout concept can be used to provide effective and accurate indicators for the future state of crisp activity relationship chart among departments. Therefore, manufacturing industrial applications of the enhanced lean layout show it effectiveness.

Keywords: Analytical hierarchy process; Simulation; Uncertainty; Lean layout.

Session C: Manufacturing Intelligence — Aug. 17, 14:50 – 16:30 (Grand Hall A, 5F)

[C1-28] Dynamic Production Control in Serial Production Systems with Queue Time Constraint Considerations

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***Abstract*—** This paper presents an admission control decision for multiple products in the process queue time (PQT) constraint problem. This indicates that the waiting time of each job in different downstream queue cannot exceed a predefined upper bound. Between some special processes makes it difficult to achieve demand targets and product yield.

A dynamic admission selection control (DASC) method is developed in this research, and the objective is to minimizing the sum of inventory holding costs and scrap costs in a multi-product manufacturing system with QT constraints. The DASC model is developed by using Markov decision processes (MDP). The DASC model generates real-time production control policies that coordinate capacity allocation and admission control decisions in production systems with multiple products and QT constraints. The robustness of DASC model is validated in numerical study. Comparing with other control methods in literature, the proposed DASC method can significantly reduce total production costs and is robust in general production environment.

Keywords: Queue time constraint; Admission control; Markov decision process; Capacity allocation.

[C2-04] Application of Critical-Siphon Theory to Fastest Deadlock Controller to Enhance the Intelligence of Semiconductor Flexible Manufacturing Systems

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***Abstract*—** This paper present a critical-siphon theory to demonstrate exactly one monitor for quality Semi-Conductor Flexible Manufacturing System (FMS) is required for the set of siphons in the family of a 2-compound siphons and how to assign its initial markings. The theory is aiming to avoid redundant monitors in Semi-Conductor FMS and the unnecessary associated computational burden so that the quality of a class of Semi-Conductor Flexible Manufacturing Systems can be assured latest in the run-time. Neither reachability graph nor minimal siphon needs to be computed achieving polynomial complexity---essential for large systems. This paper re-develops the theory more formally and further applies this approach to two well-known S3PR to obtain a controller full or near maximally permissive in the context of deadlock resolution and Quality Assurance.

This paper further categorizes mixture siphons into partial and full ones and the sequence among them to add monitors associated with one or different 2-compound siphons. As a result, there is no need to enumerate all siphons and the time complexity involved is polynomial. This is the first of its kind of works among all current results on the benchmark.

Keywords: Critical-siphon theory; Flexible manufacturing system (FMS); Deadlock; Polynomial complexity, S3PR.

[C3-25] Planning of Preventive Maintenance Activities: Incorporating Imperfect Maintenance into a G/G/m Queueing Model with Multiple Maintenance Cycles

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***Abstract*—** Preventive maintenance (PM) activities are essential in every manufacturing industry. PMs serve to reduce unexpected failures, improve overall availability and ensure reliability of production. As manufacturing equipment has increased in complexity, especially in high technology industries such as semiconductor manufacturing, PM task complexity, difficulty and duration have increased. As such, the probability that each PM is successful the first time it is conducted has decreased. This fact is complicated by the tendency for such imperfect PM tasks to only be discovered when the tool is tested in the preproduction qualification stage. At this point, the failed task must be identified and corrected.

With the goal of application to the planning of PMs in semiconductor manufacturing equipment, a G/G/m queueing model allowing imperfect PMs with a single cycle (e.g., one PM every month and no other kinds of PMs) was developed in Kalir (2013). In Morrison et al. (2014), the model of Kalir (2013) with reliable PMs was extended to allow for multiple PM cycles (e.g., one kind of PM every month and another kind of PM every three months).

Here we discuss how to extend the work of [2] to include imperfect PM tasks. We focus on a G/G/m based model allowing for multiple types of PMs that are each imperfect. Each PM task is modeled with fixed probability of success. A group of tasks makes up a single PM and requires a setup. The model is used to develop a nonlinear optimization problem that seeks to minimize the cycle time in the G/G/m queue model. The model may be of use for the planning of PMs in semiconductor manufacturing equipment.

Keywords: Preventive maintenance; Cycle time optimization; Nonlinear programming; Imperfect PMs.

[C4-02] Analysis and Approximation of Dual Tandem Queues with Finite Buffer Capacity

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***Abstract*—** exist in practical applications. By viewing a tandem queue as an integrated system, a general approach has been developed to analyze its queue time performance through the insight from Friedman's reduction method. Fundamental properties of a finite buffer tandem queue are examined. We show that in general system service rate of a dual tandem queue with finite buffer capacity is equal or smaller than its bottleneck service rate, and virtual interruptions, which are the extra idle period at the bottleneck caused by the non-bottlenecks, depend on arrival rates. Hence, system service rate is a function of arrival rate when the buffer capacity of a tandem queue is finite. Approximation for the mean queue time of a dual tandem queue has been developed through the concept of virtual interruptions.

Keywords: Queueing; Tandem queue; Finite buffer capacity.

[C5-12] Parameterizing Dispatching Rules for Dynamic Complex Job Shops Using Local and Global Information

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***Abstract*—** We study parameterization schemes for composite dispatching rules in wafer fabs. The parameterization of the Apparent Tardiness Cost with Setups (ATCS) dispatching is based on a local grid search, a regression approach based on local information, and a global grid search approach. The performance measure of interest is the total weighted tardiness. A simulation study is carried out to compare the different approaches. It turns out that the global grid approach slightly outperforms the remaining approaches if the product mix information is accurate. However, the latter condition is crucial. The two local approaches perform close to the global approach, but global information with respect to product mix is not required.

Keywords: Complex job shop; Composite dispatching.

Session D: Manufacturing Excellence — Aug. 17, 14:50 – 16:30 (Pascal, 5F)

[D1-08] Reduced Modeling Approach for Semiconductor Supply Chains

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***Abstract*—** The global supply chains of semiconductor manufacturers include buffers related to demand, equipment, inventory, and network design to allow reacting on volatility in business requirements and capacity availability. These buffers are cost-intensive and their optimization is supposed to reveal saving potentials. In this paper, we present the conceptual foundation for a comprehensive network model to simulate the inter-dependencies of the buffers. A reduced modeling approach of the fabrication facilities is proposed to keep both the modeling effort and the computing time low. An application scenario is showed that addresses some aspects of production speed-up by means of lot prioritization.

Keywords: Simulation; Supply chains; Reduced models.

[D2-09] Wafer Fabrication Capability Assessment - Opportunities and Challenges to Improve Responsiveness–a View from the Trenches

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***Abstract*—** the question that torments wafer fabrication (fab) management is Fab Capability Assessment – estimating (committing) what the fab can accomplish under various conditions or what needs to be done to meet specified targets. The need is: fast effective responsiveness without confusion. There are a myriad of questions and modeling approaches. Forward progress in the use of "analytics" to support these decisions is sporadic. Our purpose includes: (a) frame the planner's question, "Which methods when / why?" (b) sketch elements of complexity that often go unnoticed, (c) draw attention to FCA aspects often underserved: (i) tool planning: deployment , time slices(migration), downtime schedules & (ii) deciding lots to expedite, (d) challenge of uncertainty (demand & production), and (e) delivery of solutions will occur within hierarchy-for organizational & computational reasons

Keywords: Tool capacity planning; Fabs; Waiting time; Hierarchical production planning; Aggregate planning.

[D3-15] A Novel Dynamic Policy for Shorting the Waiting Time of Big Jobs

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Abstract- Computer experiments is an important tool in the development of advanced technology for getting a good understanding to the relationship between an interesting response and the related parameter setting. In particular, the process of semiconductor got more complicated with each passing day, and therefore the computer experiments are widely and greatly used in the field of semiconductor manufacturing. As a result, it is hard-pressed to get the required resource to conduct the computer experiments especially for the big jobs namely the jobs that requiring large resource. Traditionally, an enterprise would buy more hardware to solve this problem, but it takes a high cost. Thus, this study proposed a dynamic resource dispatching policy to solve the problem in order to reduce the average leisure time of the available resource for improving the efficiency of computer system. The proposed system had been validated by a real case of a leading IC design corporation in Taiwan.

Keywords: Dispatch policy; Computer experiments; Semiconductor manufacturing; Multitasking.

[D4-37] Development of a Simulation System for Semiconductor Capacity Planning

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Abstract- Production planning and scheduling are extreme challenging for semiconductor industry due to its manufacturing complexity, this research intends to present a systems analysis and design approach for developing a semiconductor capacity planning simulation system. In this paper, the features of semiconductor capacity planning are first analyzed, then we use model-driven architecture (MDA) approach to develop the simulation system in which context diagram, use-case diagram, use case narrative, activity diagram, sequence diagram are employed. Based on the systems analysis, a commercial available object-oriented simulation software, Plant Simulation, is employed to develop the proposed simulation system. Finally, the capacity planning simulation system is applied in a 12" semiconductor manufacturing company.

Keywords: Semiconductor capacity planning; Simulation systems development; MDA (Model-Driven Architecture).

[D5-33] Electricity Costs and Minimizes Idle Time Production Control Mechanisms: A Case Study of TFT-LCD Array Metal Process

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Abstract— In the case of gradually rising power costs, reducing electricity costs is an important goal of the enterprise, this research studies the problem of minimizing idle time at the bottleneck equipment and electricity costs of a TFT-LCD Array Metal process and proposes two different production control mechanisms: (1) Reduce production quantities during Peak Load time, and (2) Allow lower safety WIP level during Peak Load time. The case study is based on actual data and combines simulation software to conduct performance tests, the results show that two proposed production control, mechanisms can lead to 6.3% and 8.2% reduction in electricity, costs, respectively.

Keywords: Variable electricity price; Production control mechanism; TFT-LCD array.

[D6-19] Total Factor Productivity of Logistics Industry: Case of Jiangxi Province

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***Abstract*—**Logistics industry is the basic industry of the whole nation, hence the overall operation efficiency of the logistics industry is attracting more attention from the governments at all levels recently. This paper takes total factor productivity (TFP) as the research object. First, the measurement model of TFP of the logistics industry in Jiangxi province is determined, and the evaluation index system is selected. Secondly, the paper statically analyzes the logistics TFP of 11 cities in Jiangxi province from 2003 to 2011 by applying DEA method. Results show that most of the cities are DEA-inefficient. Then, the paper dynamically analyzes Malmquist index, technical efficiency and technology progress rate of 11 cities and four economic zones in Jiangxi province from 2003 to 2011 by using software DEAP2.1. Results indicate that technological progress is the key to Malmquist index growth. These results can provide enlighten for Jiangxi province to formulate logistics industry policies and improve the efficiency of the overall logistics activities operation.

Keywords: Total factor productivity; Logistics industry; DEA; Malmquist index.

Session E: Quality Engineering — Aug. 17, 14:50 – 16:30 (Voltaire, 5F)

[E1-36]Automatic Recognition of Defect Patterns in Semiconductor Wafer Bin Maps

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Abstract-The lengthy process of manufacturing semiconductors involves hundreds of steps, during which big data including the wafer lot history, recipe, inline metrology measurement, equipment sensor value, defect inspection, and electrical test data are automatically generated and recoded. Semiconductor companies experience challenges integrating big data from various sources into a platform or data warehouse, and lack intelligent analytics solutions to extract useful manufacturing intelligence and support decision making regarding production planning, process control, equipment monitoring, and yield enhancement.

Circuit probe (CP) testing is used to evaluate each die on the wafer after the wafer fabrication processes. Wafer bin maps (WBMs) represent the results of a CP test and provide crucial information regarding process abnormalities, facilitating the diagnosis of low-yield problems in semiconductor manufacturing. In WBM failure patterns the spatial dependences across wafers express systematic and random effects. Various failure patterns are required; these pattern types facilitate rapidly identifying the associate root causes of low yield. Based on the defect size, shape, and location on the wafer, the WBM can be expressed as specific patterns such as rings, circles, edges, and curves.

In practice, thousands of WBMs are generated for inspection and engineers must spend substantial time on pattern judgment rather than determining the assignable causes of low yield. Io effectively transfer observed defect pattern on WBM into meaningful information or knowledge for process improvements and yield enhancements in the semiconductor industry. In practice, many companies still rely on experienced engineers to judge WBM pattern, which is not only time-consuming, but also inefficient and inconsistent owing to human fatigue. In addition, the complicated processes and diverse products fabricated in semiconductor manufacturing can yield various pattern types including different chip size, defect density, wafer rotation and noise degree, and lead to complicatedly detect systematic patterns by using only eyeball analysis.

Additionally driven by continuous migration of semiconductor manufacturing technology, increase of wafer size and shrinkage of critical dimensions have led the WBM patterns from basic types such as center, circle, and ring to more complicated that cannot be easily classified for the composite types It becomes more difficult to classify the defect pattern to the right pattern. Recently, some automated techniques based on neural network, machine learning technique are proposed to recognize specific patterns, but amount of training samples are necessary in order to identify and classify patterns. However, little research has been done on recognition of complicated WBM with various defect density, noise degree, and pattern size.

This study aims to propose an intelligent method to recognize complicated WBMs, in which the recursive tracking method was used to extract specific patterns on a wafer and mountain function algorithm was used to convert WBM into numerical dimension. Then, the selected WBM was used to compare with defect pattern templates through dynamic time warping algorithm. We conducted a numerical experiment by considering six typical WBMs pattern from a wafer fabrication to demonstrate the effectiveness of the proposed method. According to the analysis result, the proposed method has better classification accuracy, specificity, and sensitivity than the existing method integrating spatial correlogram algorithm and dynamic time warping.

Keywords: Wafer bin map; Pattern recognition; Recursive tracking method; Dynamic time warping.

[E2-13] Monitoring Wafer Geometric Quality using Additive Gaussian Process Model

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Abstract-Wafer geometric quality is an important quality characteristic in the semiconductor industry. However, it is difficult to monitor the geometric quality in the manufacturing process due to the challenges raised from the complexity of the data structure. In this article, we propose an additive Gaussian process (AGP) model to approximate the standard wafer geometric profile while quantifying the deviations from the standard when manufacturing process is in control. Based on the AGP model, two statistical tests are developed to determine whether a newly produced wafer is conforming or not. We have conducted extensive numerical simulations and real case studies, the results of which indicate that our proposed method is effective and has potentially wide applications.

Keywords: Geometric quality; Gaussian process; T^2 test; Generalized likelihood ratio test.

[E3-06] LED Packaging Process Monitoring using a CUSUM chart based on Zero-inflated Binomial Distribution

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Abstract—The numbers of non-conformities in a batch with varying batch sizes in the light-emitting dioide (LED) process can be modeled with a zero-inflated binomial (ZIB) distribution. In this paper, we proposed a cumulative sum (CUSUM) chart for monitoring the abnormal shifts in LED packaging processes. The control limit of the CUSUM chart is obtained via simulation methods under an assumption that the batch size (number of defect opportunities in each batch) follows a uniform distribution. Simulation results show that the proposed control chart is sensitive to the shifts in either of the two parameters in a ZIB process based on average number of observations to signal (ANOS). Finally a case study based on the data collected from a LED packaging process is presented. The results from the case study also show that the proposed CUSUM chart is effective in detecting abnormal shifts in the process.

Keywords: Zero-inflated binomial; Average number of observations to signal; Cumulative sum chart; Light-emitting diode packaging.

[E4-32] A Hybrid Chart to Detect Increased Incidence Rate under Unequal Population

Chien-hung Lin and Chen-ju Lin*

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***Abstract*—** Monitoring the number of incidence has many applications in different fields like agricultural pests, disease, or quality control. Detecting the increased incidence rate is one of the most important objectives of spatiotemporal surveillance. Define a cluster as the region in which the incidence rate increased from a baseline rate calculated by using stationary data. Timely signaling the existence of clusters and identifying their geographical locations would assist decision makers in setting up the policies for controlling or preventing the spread out of clusters. The out-of-control disasters may then be avoided. Accordingly, analyzing the incidence rate could promote public benefits or health, or reduce manufacturing costs depending on the field of applications. This research focuses on analyzing the number of incidence which follows Poisson distribution in spatiotemporal surveillance. The mean and variance of a Poisson random variable equal to its Poisson rate. The population size at risk, however, is often non-homogeneous in practice. The population size at risk may change across time or space, which makes detecting the increased incidence rate challenging. It has been observed that a cluster under the region with a larger population size at risk is easier to be detected than that under a smaller population size. The detection capability of a spatiotemporal surveillance method would be influenced by the population size at risk. For purpose of fairness, the detection capability is required to be invariant to the population size at risk in many application fields. For example, a disease cluster occurring in a low population density city deserves equal detection as that occurring in a high one. A defect pattern with a small coverage size may be as important as that with a large coverage size on wafers. Many existing works studied the impact of population size to detection time based on the likelihood-ratio (LR) methods. Several modifications were made to adjust for non-homogeneous population size. However, different modifications are appropriate under different population distributions. Since the geographical locations of clusters are unavailable, the population sizes of the existing clusters cannot be known in advance. Choosing a wrong spatiotemporal surveillance method may delay the time to detection. Accordingly, this research proposes a hybrid control chart to detect increased incidence rate in Poisson spatiotemporal data with non-homogeneous population size at risk. Two charting statistics that are based on incidence count and rate are proposed for spatiotemporal surveillance. By combining the advantages of the two statistics, the proposed hybrid control chart can generally perform well regardless of the population distribution of the existing clusters.

Keywords: Poisson distribution; Spatiotemporal scan statistics; Surveillance analysis.

[E5-05] Detecting Multiple Change Points of Nonparametric Profile by Nonlinear Dimension Reduction

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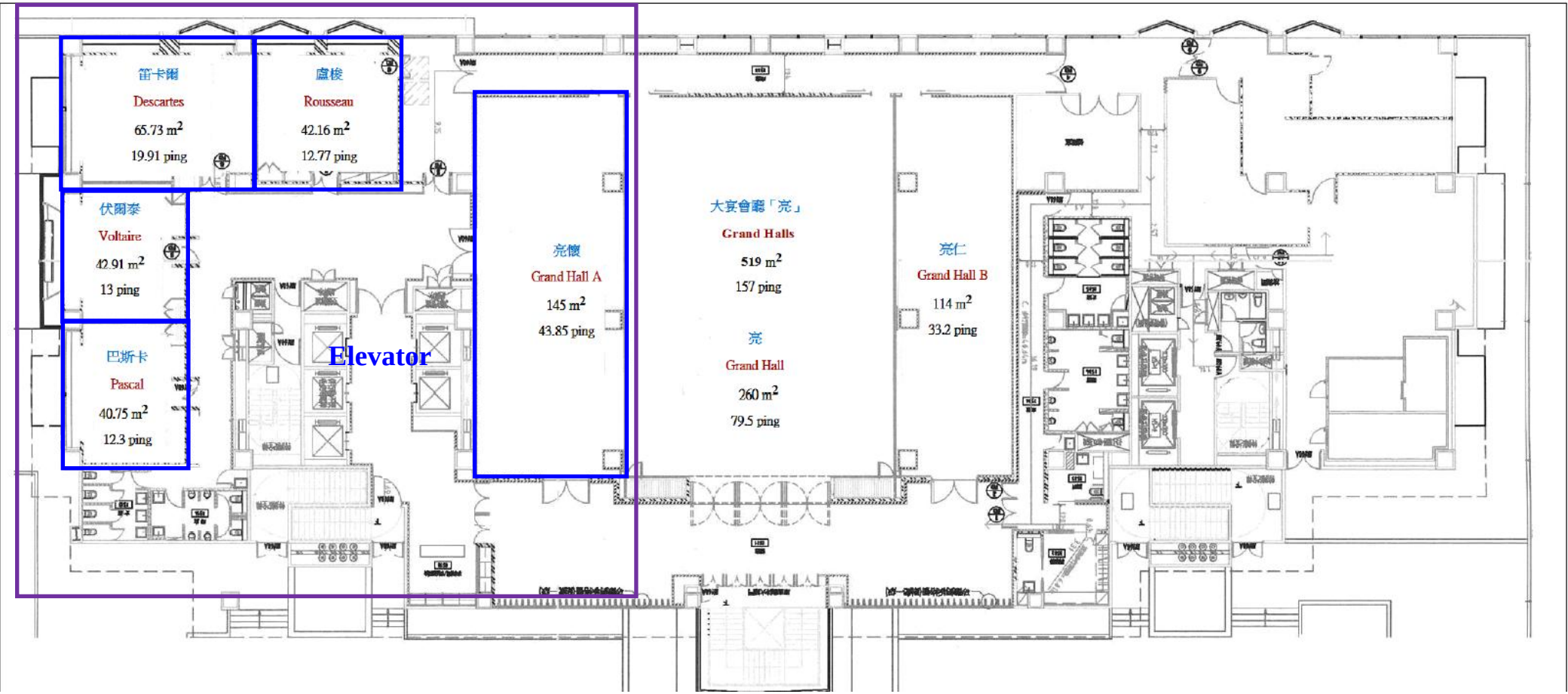
***Abstract*—** Dimension reduction has been used to identify change points of the relationship of response variables and explanatory variables in many applications. Nonlinear dimension reduction technology could keep pattern detail of high dimension variation. In this article, we propose a multiple change points detection method in Phase I for nonparametric profile based on nonlinear dimensionality reduction technique. The proposed procedure incorporate locally linear embedding (LLE) into a multiple change point detection method. The new method has better performance than principal component analysis (PCA) based approach through simulation performance analysis. Case study result shows that the lower misidentification rate on the change points location estimation could be obtained than comparison methods.

Keywords: Nonparametric profile; Change point detection; Locally linear embedding.

Introduction to STEP Consortium

STEP Consortium (Semiconductor Technologies Empowerment Partners Consortium) is sponsored by Ministry of Science and Technology, Taiwan to address emergent industry needs and critical research issues for advanced intelligent manufacturing and operational excellence for semiconductor industry. Principal Investigator, Tsinghua Chair Professor Chen-Fu Chien, and Co-PIs, Professor Jei-Zheng Wu, Professor Chia-Yu Hsu, and Professor Chia-Yen Lee, have led associates and research team members to conduct various university-industry collaborative research projects with members and sponsoring companies to solve real world problem including Taiwan Semiconductor Manufacturing Company (tsmc), Macronix, MeadiaTek, Global Unichip, Visera, Epistar, Delta, Qunata Computer, and Vanguard in various high-tech industries. We also established the NTHU-TSMC Center for Manufacturing Excellence to empower our joint research efforts, including organizing the Semiconductor Big Data Contest that we have developed an ecosystem to integrate vertical players of the value chains of big data analytics including tsmc, Acer, IBM, SAS, Hadoop, and other IT/software companies. We also organized conference such as ISMI (International Symposium for Manufacturing Intelligence) and training program such as Tsinghua IC School.

ISMI2014 Location Map:
5 Floor, Palais de Chine Hotel, Taipei, Taiwan



ISMI 2014
International Symposium on
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Computers & Industrial Engineering

Special Issue on

Manufacturing Intelligence and Automation in the Semiconductor Industry

Aims:

Semiconductor industry is a critical industry that contributes substantially to the global economy. Semiconductor industry has been exponentially growing with technology migration and cost reduction and has found different applications including computers, communication, consumer electronics, green energy, car electronics, and medical electronics. Semiconductor manufacturing is one of the most complex manufacturing processes due to tightly constrained production processes, reentrant process flows, sophisticated equipment, volatile demands, and complicated product mix. While big data is accumulated due to the fully automated manufacturing facilities and logistics systems for business integration, various solutions and techniques have been developed to extract useful information and derive effective manufacturing intelligence with advanced decision technologies to address new challenges. By combining equipment automation with decision technologies and exploiting useful rules and patterns from data, potential failures during the early stages will be anticipated in possible situations rather than reacting. In particular, the intelligence and real-time decision-making capabilities of equipment coupled with the system-level fabrication automation in semiconductor manufacturing have changed the paradigm of high-tech manufacturing. Additional opportunities are made available by state-of-the-art computers and novel industrial engineering approaches. Thus, this special issue of the *Computers & Industrial Engineering* (**C&IE**) aims to address the critical issues involved in manufacturing intelligence and automation in the semiconductor industry and other high-tech industries.

Scope:

Topics to be covered include, but are not restricted to the following aspects of manufacturing intelligence and automation for semiconductor manufacturing and high-tech industries:

- Advanced equipment/process control (AEC/APC)
- Automated material handling systems (AMHS) Routing & Scheduling
- Automation in 450mm wafer generation
- Big Data Analytics & Data mining
- Decision technologies for equipment automation
- Intelligent Corporate Resource Planning & Allocation
- Design for manufacturing (DFM)
- e-Manufacturing
- Equipment diagnosis and Tool Health
- Equipment engineering systems (EES)

- Equipment productivity
- Equipment Real-time Decision
- Applications of computational Intelligence to Semiconductor Manufacturing
- Factory modeling, analysis and performance evaluation
- Green Supply Chains
- Manufacturing Innovation
- Manufacturing Intelligence & Manufacturing Informatics
- Modeling & Decision Analysis for Semiconductor manufacturing
- Mobile and wireless applications (RFID)
- Intelligent systems
- Predictive Maintenance
- Semiconductor Ecosystem & Manufacturing Strategy
- Simulation Optimization
- Yield enhancement systems and e-Diagnosis

Submission Guidelines:

Original, high quality research papers and empirical studies presented in **the 2014 International Symposium on Manufacturing Intelligence (ISMI2014), Taipei, Taiwan, August 16-18, 2014** will be invited, while other papers can also be directly submitted, for regular review and potential publication in this special issue. All papers must be original and have not published, submitted and/or currently under review elsewhere. All manuscripts should be submitted through the Elsevier's online system at http://ees.elsevier.com/caie/. Please choose "**Semiconductor Mfg Intel & Auto**" as Section/Category when assigning the Article type. In preparing their manuscript, the authors are asked to closely follow the "Instructions to Authors"**.** Submissions will be refereed according to the **C&IE** standards and usual procedures, subject to blind peer review by at least two referees. Accepted papers become the property of **C&IE** publisher.

Publication Schedule (tentative):

Deadline for manuscript submission:	31 October, 2014
Review report:	31 December, 2014
Revised paper submission deadline:	31 March, 2015
Notification of final acceptance:	31 May, 2015
Approximate publication date:	October 2015

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International Journal of Industrial Engineering: Theory, Applications and Practice

Special Issue on

The Roles of Industrial Engineers in the Semiconductor Industry

Aims of the Special Issue:

The semiconductor industry has been continuously growing with the various applications including medical electronics, green energy, car electronics, computers, communication, and consumer electronics. Semiconductor manufacturing is an extensively complex process comprising tightly constrained production processes, reentrant process flows, expensive sophisticated equipment, uncertain demand, and variable supply. Industrial engineers have been contributing knowledge of enabling business and operations decision excellence. With the emergence of larger-scale automated factories and even more complex manufacturing owing to higher technology advancement, there is a compelling trend to extend the industrial engineering scope to integrate with advanced decision technologies for higher decision quality. This special issue of the *International Journal of Industrial Engineering: Theory, Applications and Practice* (**IJIETAP**) aims to review the roles of industrial engineers involved on recent progress in the semiconductor industry and to point out the research trend toward the enhancement of the semiconductor industry.

Scope of the Special Issue:

A main source of the manuscripts in this special issue will be invited from those high quality papers and empirical research papers presented in **The 2014 International Symposium on Manufacturing Intelligence (ISMI2014), Taipei, Taiwan, August 16 – August 18, 2014**, while other papers describing scientific technologies and methodologies that improve the quality of business and operations decisions of the semiconductor industry can also be directly submitted, for regular review and potential publication in this special issue. Special attention will be paid to papers focusing on reviewing the roles of industrial engineers in the semiconductor industry. Submissions of comprehensive reviews and tutorial survey from experts in academia and the semiconductor industry worldwide are strongly encouraged. Topics to be covered include, but are not limited to:

- Industry ecosystem and supply chains
- Integration and virtual integration
- Business models
- Decision technologies and methodologies
- Fault diagnosis and predictive maintenance
- Design for manufacturing (DFM)

- Factory modeling, analysis and performance evaluation
- Capacity and inventory management
- Planning, scheduling, and coordination
- Job release and dispatch policies
- Automated/Manual material handling systems (AMHS/MMHS)
- Factory/cell/equipment-level controller design
- Manufacturing execution systems (MES)
- Advanced process control (APC)
- Decision support systems (DSS)
- Transportations and logistics
- Human resource management
- Human factors and ergonomics
- Productivity improvement
- Yield enhancement systems and e-Diagnosis
- Equipment engineering systems (EES)
- Automation and remote control
- Cloud, mobile and wireless applications
- Agent based intelligent systems

Submission Guidelines:

All papers must be original and not published, submitted and/or currently under review elsewhere. All manuscripts should be submitted through the **IJIETAP** online system at http://journals.sfu.ca/ijietap/index.php/ijie/about/submissions#onlineSubmissions. Please choose "**ISMI2014**" when assigning the Journal Section. In preparing their manuscript, authors are asked to closely follow the online "Author Guidelines"**.** Submissions will be refereed according to the **IJIETAP** standards and requirement. Each paper submitted will be subject to a blind peer-reviewed by at least two referees, in accordance with usual **IJIETAP** procedures. If accepted, a Word file of the final paper must be emailed to the corresponding guest editor. Papers accepted become the property of **IJIETAP** publisher.

Publication Schedule (tentative):

Deadline for manuscript submission:	**2014/09/30**
Review report:	2014/12/31
Revised paper submission deadline:	**2015/03/31**
Notification of final acceptance:	2015/04/30
Approximation publication date:	**2015/12**

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Special Issue on

Big Data Analytics for Systems Control and Decision Making in Services and Manufacturing

Submission Deadline: March 31, 2015

Almost all companies in service and manufacturing industries are confronted with the challenges for effective decisions induced by big data. While big data is accumulated due to the fully automated manufacturing facilities, logistics, service systems, and e-business for business integration, various solutions and techniques have been developed to extract useful information and derive effective intelligence with advanced decision technologies to address new challenges. By seamless integration of intelligence, modeling, and decision technologies combined recent data mining methodologies, computing power, data management and IT technology, big data analytics have become the trend to empower future service and manufacturing.

This special issue of the *Flexible Services and Manufacturing (FSM) Journal* aims to address recent developments and empirical studies of big data analytics and related topics and to examine research issues concerned with quantitative and other modeling techniques to improve the decision quality and management effectiveness for service and manufacturing. We are seeking papers that present new research contributions in this field, preferably illustrated by real world examples. Papers for this Special Issue must make a substantial new contribution, and the authors must explicitly show the scientific advances compared to the previously published research literature. Topics include (but are not limited) to areas such as the following:

- Advanced Equipment/Process Control (AEC/APC)
- Big Data Analytics for Manufacturing Innovation
- Big Data Analytics for Service Innovation and Product Design
- Business Analytics and Optimization
- Data Mining for Energy Saving and Green Production
- Data Mining and Real-time Decision
- e-Manufacturing and e-Diagnosis
- Engineering Data Analysis and Data Mining for Yield Enhancement
- Intelligent Corporate Resource Planning & Allocation
- Modeling & Decision Analysis for Service and Manufacturing
- Predictive Maintenance and Tool Health
- Sensor, Mobile and Wireless Applications
- Simulation Optimization
- Empirical Studies of Big Data Analytics and Computational Intelligence

Submission Guideline

Original, high quality research papers and empirical studies presented in **the 2014 International Symposium on Manufacturing Intelligence (ISMI2014), Taipei, Taiwan, August 16-18, 2014** will be invited, while other papers can also be directly submitted, for regular review and potential publication in this special issue. Papers must clearly address research issues of Big Data Analytics for Systems Control and Decision Making in Services and Manufacturing. Please submit your paper online via

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and use "**Big Data Analytics**" as article type. The target print publication date is Spring 2016. Accepted papers appear on Springer's webpage prior to print publication.

The submitted papers must not have been previously published or be currently under consideration for publication elsewhere. All papers will be reviewed according to the standards of the FSM journal. We will adopt a rapid and fair review process in order to meet the target publication date. Please feel free to contact the editors with any questions.

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