2017 INTERNATIONAL CONFERENCE ON FRONTIERS OF CHARACTERIZATION AND METROLOGY FOR NANOELECTRONICS

THE 11TH CONFERENCE IN THE SERIES!

MARCH 21-23, 2017

MONTEREY, CALIFORNIA

DAVID G. SEILER, FCMN CO-CHAIR

CHIEF, ENGINEERING PHYSICS DIVISION

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

FCMN COMMITTEE

- **Co-Chairs**
  - David Seiler, NIST;
  - Alain Diebold, CNSE, SUNY Polytechnic Institute;
  - Zhiyong Ma, Intel; and
  - Bob McDonald, formerly of Intel (Treasurer)
- **Committee Members**
  - Amal Chabli, CEA-Leti
  - Luigi Colombo, TI
  - Michael Current, Current Scientific
  - Ajey Jacob, Global Foundries
  - Scott List, SRC
- **Committee Members**
  - Shifeng Lu, Micron
  - Ulrich Mantz, Zeiss
  - Lori S. Nye, Brewer Science, Inc.
  - Yaw Obeng, NIST
  - Shinichi Ogawa, AIST
  - Lothar Pfitzner, Fraunhofer IISB
  - Erik Secula, NIST
  - Wilman Tsai, TSMC
  - Wilfried Vandervorst, IMEC
  - Usha Varshney, NSF
  - Victor Vartanian, ISMI
  - Ehrenfried Zschech, Fraunhofer IKTS Dresden

FCMN PARTNERS

PLATINUM SPONSOR

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EXHIBITORS

Bruker	NanoAndMoore USA Corp.
CAMECA Instruments, Inc.	NIST
Frontier Semiconductor	SAES Group
Intel	Xenocs

WHAT A DELIGHT TO BE IN MONTEREY!
(AND, OF COURSE, NEAR BY SILICON VALLEY)

FCMN LOCATIONS

- 1995, 1998, 2000, 2007, 2013: NIST, Gaithersburg, MD
- 2003: J.J. Pickle Research Campus, Univ. of Texas, Austin, TX
- 2005: Univ. of Texas at Dallas, Richardson, TX
- 2009: College of Nanoscale Science and Engineering, SUNY, Albany, NY
- 2011: MINATEC Campus, Grenoble, France (CEA-Leti)
- 2015: Dresden, Germany (Fraunhofer)
- 2017: Monterey, California

ORGANIZATIONS REPRESENTED (UPDATED MAR. 14)

46 DIFFERENT COMPANIES, 21 DIFFERENT UNIVERSITIES, 9 DIFFERENT GOVERNMENT/RESEARCH INSTITUTES
76 TOTAL

- Advantest
- AIST
- AkzoNobel
- Anasys Intruments
- Applied Materials
- ASML
- Attolight
- Bruker
- Cal Poly Pomona
- Cameca Instruments
- CAPRES A/S
- Carl Zeiss
- Cascade Microtech
- CEA LETI
- Columbia University
- Current Scientific
- Cypress
- Delft Univ of Technology
- DTU Nanotech
- EAG Laboratories
- ETH Zurich
- Excillum
- Femtometrix
- Floris/St Microeelectrinics
- Fraunhofer
- Frontier Semiconductor
- Gatan
- George Mason Univ
- Ghana Atomic Energy Commission
- Global Foundries

ORGANIZATIONS REPRESENTED (UPDATED MAR. 14) (CONTINUED)

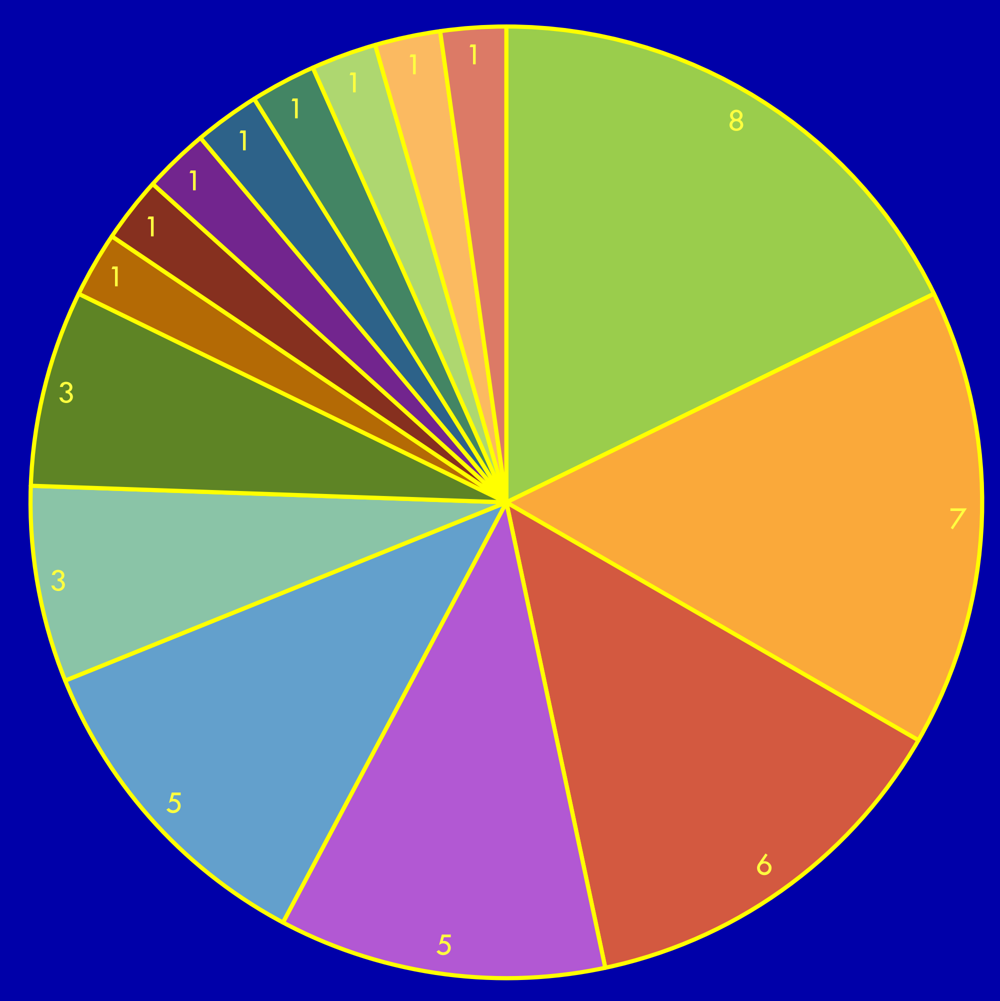
- Hamamatsu Corp.
- Hermes High-technologies
- HZDR
- IBM
- IBM T. J. Watson
- IMEC
- Intel
- Jabil
- Jared Univ
- JILA
- KLA-Tencor
- KAIST
- Kratos Analytical
- Lam research
- Lyncean Technologies
- Moelcular Vista
- Nanolab Technologies
- NanoMEGAS USA
- Nanometrics
- National Cheng Kung Univ
- National Taiwan Univ
- National University of Singapore
- New Mexico State Univ
- NIST
- Northrop Grumman
- Nova measurement
- NSF
- Park Systems
- POLLEN Metrology
- PTB

ORGANIZATIONS REPRESENTED (UPDATED MAR. 14) (CONTINUED)

- Rutgers
- SAES Group
- Sandia
- Solid State Technology
- Sony
- SRC
- SUNY Polytechnic
- Tech Insights, Inc.
- Technical Univ. of berlin
- Thermo Fisher
- TNO
- Toshiba Corp.
- TSMC
- UC Santa Barbara
- UCLA
- Univ Illinois
- Univ of Cal Davis
- Univ of Cal San Diego
- Univ of Missouri
- Univ of Nebraska – Lincoln
- Univ of Texas Austin
- Univ of Texas Dallas
- VLSI Research
- WaferMasters
- Western Digital
- Xenocs
- Yangtze memory Technology

2017 ATTENDEES BY COUNTRY (UPDATED MAR. 14)

15 DIFFERENT COUNTRIES



Germany · Netherlands · Japan · Belgium · France · Denmark · R.O.C. Taiwan · Canada

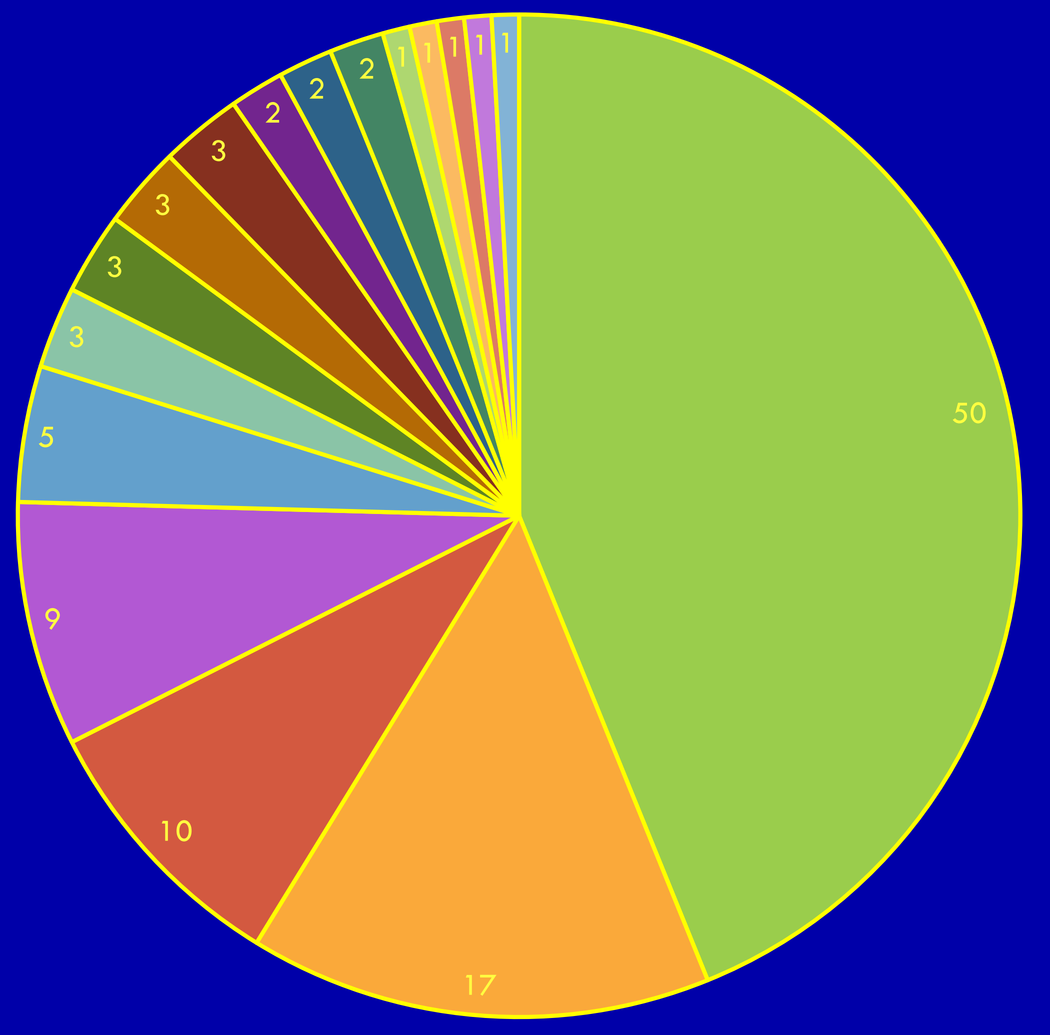
China

Ghana · Poland · Singapore

South Korea · Sweden · Switzerland

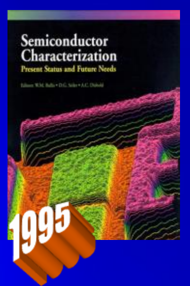
2017 ATTENDEES BY STATE (UPDATED MAR. 14)

17 DIFFERENT STATES

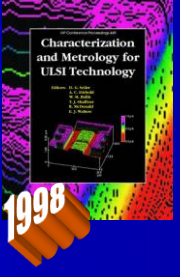


FOCAL POINT FOR FRONTIERS OF SEMICONDUCTOR NANOELECTRONICS METROLOGY

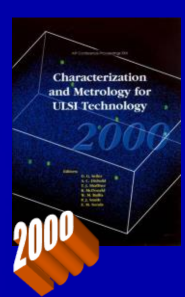
Proceedings Document Metrology Advances



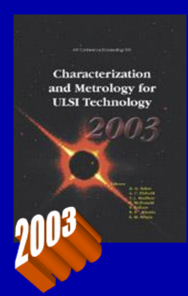
> 280 attendees



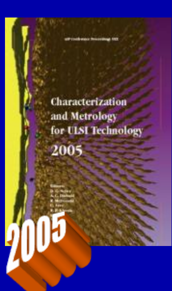
> 295 attendees



> 235 attendees



> 200 attendees



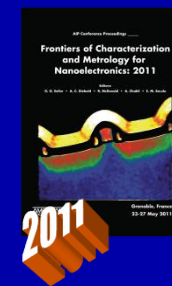
> 250 attendees

> 230 attendees

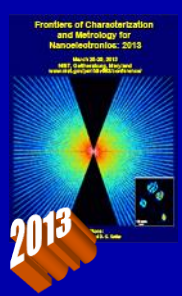
Frontiers of Characterization and Metrology for Nanoelectronics: 2009

2009

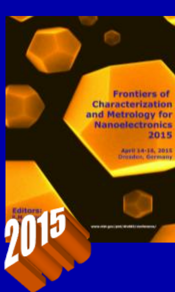
> 175 attendees



> 145 attendees

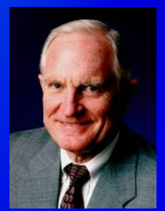


> 165 attendees



> 140 attendees

Some Keynote Speakers



Craig Barrett, formerly President, Intel

Mark Melliar-Smith, formerly President and CEO of SEMATECH

Dennis Buss, VP, Silicon Tech. Development, Texas Instruments

Bob Helms, formerly President and CEO of SEMATECH

Michael Polcari, President and CEO of SEMATECH

Mark Durcan, COO of Micron

Tze-Chiang (T.C.) Chen, IBM Fellow and VP, Science & Technology

Michel Brillouet, Senior Advisor, CEA-LETI

Mike Mayberry, VP, Intel

Klaus von Klitzing, Max-Planck-Institut FKF

ARCHIVED PAPERS AND TALKS FREE ON-LINE!

- Proceedings papers from 1998-2009 are available free of charge, thanks to an agreement between the National Institute of Standards and Technology (NIST) and the American Institute of Physics (AIP)
- Presentation slides from most of the invited talks from 2000-2015 are available
- Most posters from the 2013-2015 conferences are available
- www.nist.gov/pml/div683/conference/archives.cfm

SNAPSHOTS FROM SEMICONDUCTOR VP EXECUTIVES

- "Transistor Scaling will continue to be an important Technology Driver in the Internet Era. But it will no longer be the sole driver: SOC Integration will be increasingly important."
  - "Technology in the Internet Era," Dennis Buss, Texas Instruments, **2000 FCMN**

- "3D Technology integration is a family of technologies enabling vertical stacking of semiconductor chips and other components. It is the next revolution in Semiconductor technology roadmap and is fundamental to staying on the path of performance improvement … The integration of 3D technology will enable performance, form factor, power savings, and cost requirements of the next generation of electronic devices."
  - "Research Challenges for CMOS Scaling: Industry Directions," T.C. Chen, IBM, **2009 FCMN**

SNAPSHOTS (CONTINUED)

- "Novel materials in complex 3D structures are here now and will be increasingly prevalent going into the future."
- "Metrology and characterization are vital to develop, improve, and control advanced manufacturing processes."
  - "Pushing Beyond the Frontiers of Technology," Mike Mayberry, VP and Director of Component Research, Intel, **2013 FCMN**

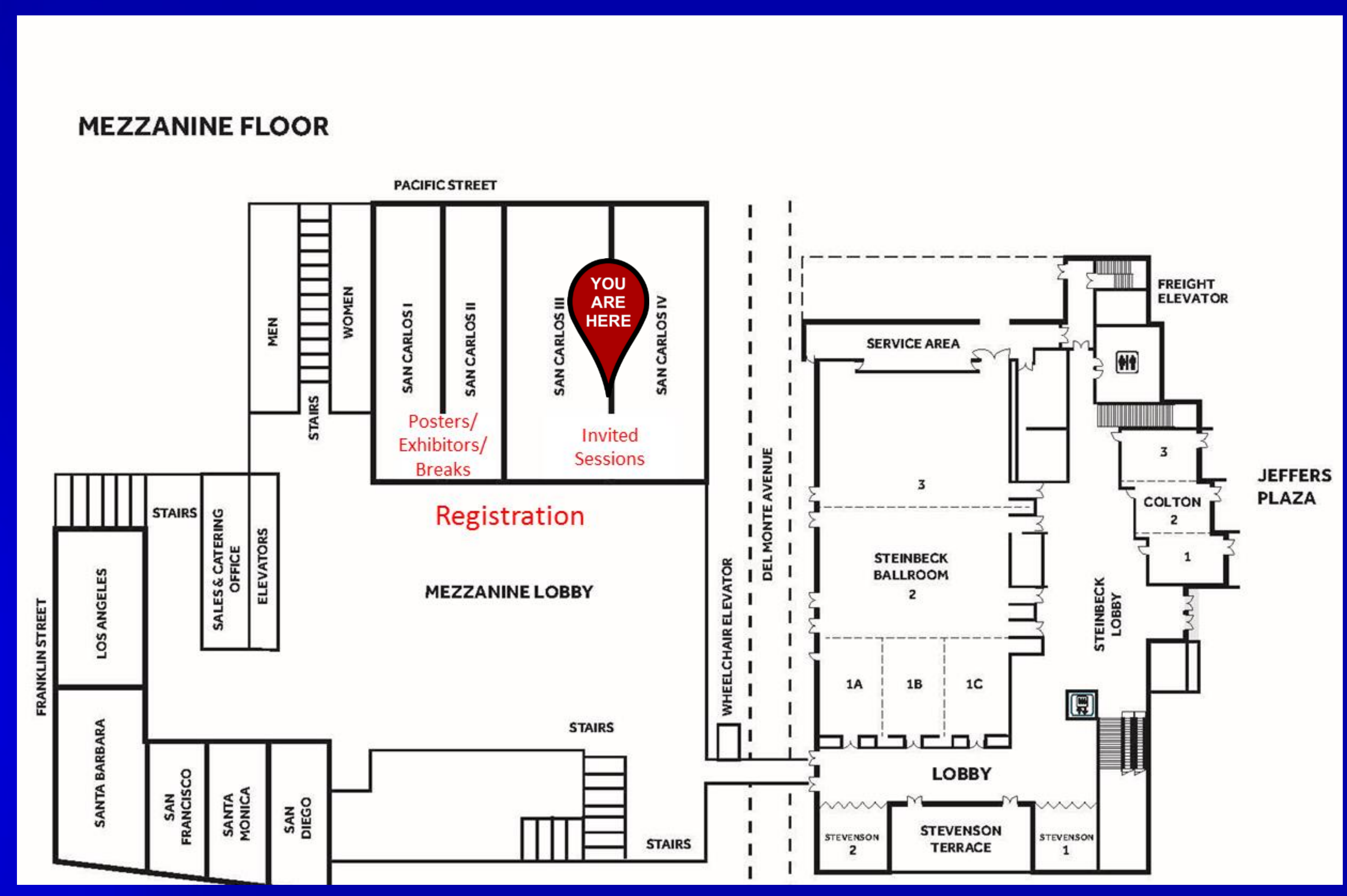
- "Emerging memory technologies present significant challenges in the area of materials and structural characterization."
- "The very act of measuring many of the emerging memory materials can change them."
  - "Characterization and Metrology Challenges for Emerging Memory Technology Landscape," Naga Chandrasekaran (VP of Process R&D, Micron) and Shifeng Lu (Micron), **2013 FCMN**

SNAPSHOTS (CONTINUED)

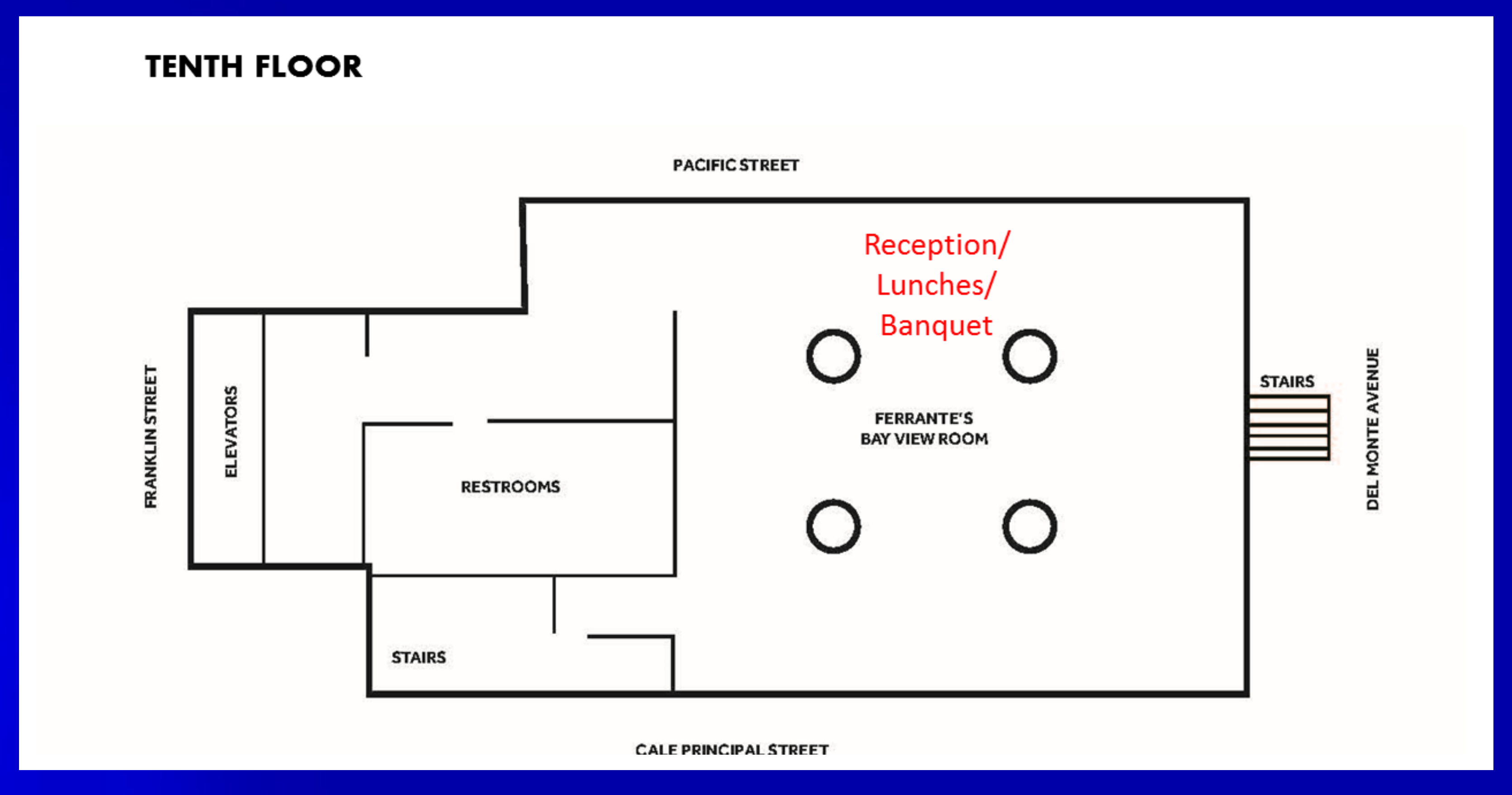
- **Pervasiveness of Metrology**
  - State of the art chip manufacturing technology nodes are approaching 2000 steps
  - Metrology and inspection steps consume a large share of these steps
    - ~50% of all steps and generally growing
  - ~25% to 33% of all the tools in the fab are metrology/defects toolsets
  - Significant fab floor space is needed for just metrology/inspection
  - CDSEM/film thickness toolsets are typically the most numerous tools in all fabs
- **Shrink puts pressure on Measurement Uncertainty**
  - Atomic level accuracy, matching and precision challenge
- **EUV Light Source and Masks**
  - New capabilities will be needed for mask defect inspection.
- **Difficult for a single metrology technique to measure all critical parameters sufficiently on 3D**
  - ***Hybrid Metrology*** emerging to fill-in gaps where individual techniques are lagging

"Techno-Economics Pressure in Semiconductor Value Chain May Impact Consumers and Global Economy – What Is Our Solution?," Suresh Venkatesan, Global Foundries, 2015 FCMN

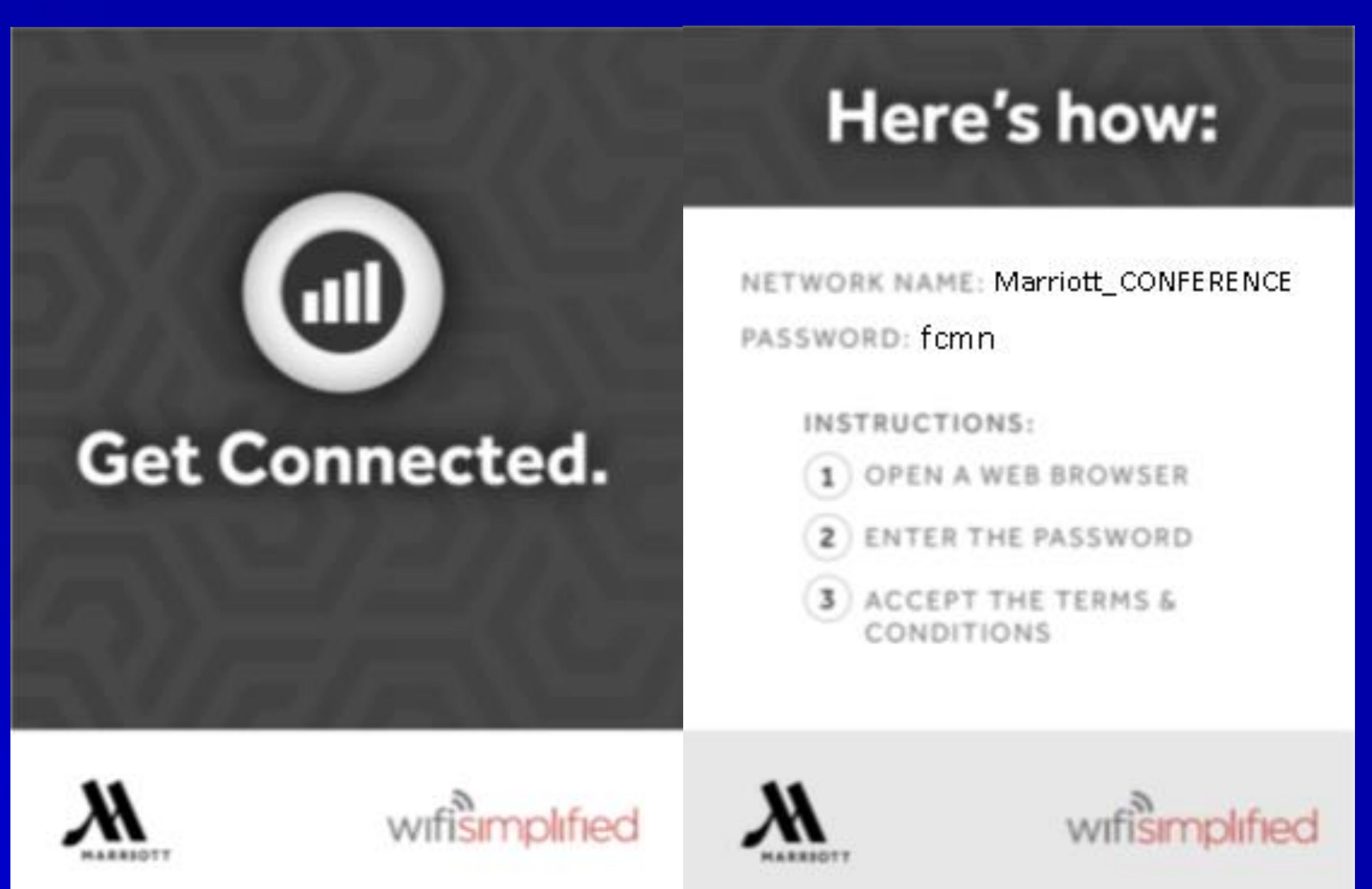
CONFERENCE FACILITIES



CONFERENCE FACILITIES



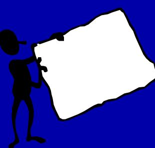
CONFERENCE WIFI



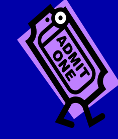
SPECIAL NOTES

- **Talks on-line**
  - We have asked each speaker for permission after the event.

- **Posters**
  - We have asked each poster author for permission to display their posters on-line. Numbers are posted above each poster. Authors are responsible for displaying and removing (by the end of lunch on Thursday) their posters.



- **Lunch/Banquet/Barbecue Tickets**
  - **If there are any lunch/event tickets you will not use, please leave them at the registration table.**



- **Silence Phones**

- **Emergency Exits**

- **Conference Survey**
  - A survey will be sent out after the event. Your feedback is appreciated!

FCMN
LATE-BREAKING
Presentation!

Gregg Profozic, Director
Advanced Manufacturing Technology
California Manufacturing Technology Consulting
"Opportunities for Beyond Silicon Nanoelectronics Through Innovative Technology Transfer"

Special Late-Breaking Metrology Session
Thursday, March 23, 2017
4:30 pm – 5:00 pm

Dan Hutcheson, CEO, VLSI Research Inc.

Aaron Thean, National University of Singapore

KEYNOTE SESSION

Session Chair: David Seiler, NIST

- **9:15 AM**
  Semiconductor Metrology: Past, Present, and the Future
  Dan Hutcheson, CEO and Chairman, VLSI Research

- **10:00 AM**
  Beyond CMOS Technologies
  Aaron Thean, VP, National University of Singapore

- **10:45 AM**
  Coffee Break and Poster/Exhibit Viewing