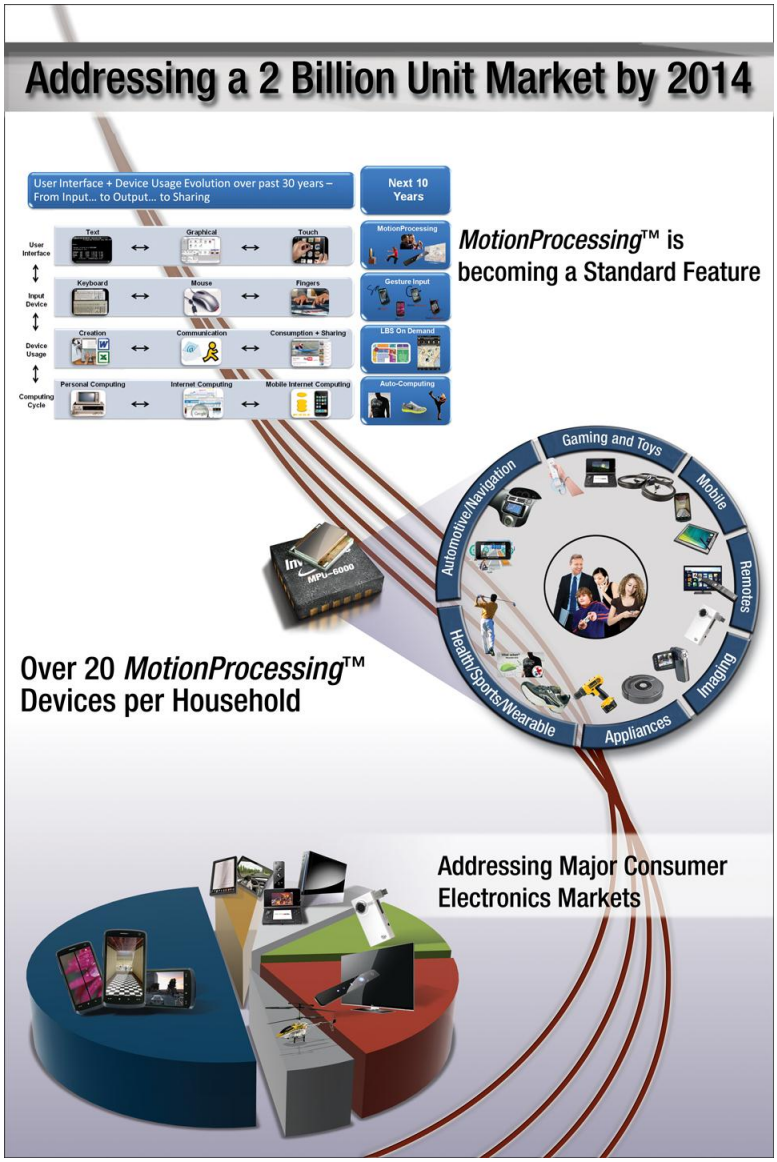
# MEMS Testing Standards: A Path to Continued Innovation

## Report on MEMS Testing Standards Workshop

## Executive Summary, September 2011




MEMS INDUSTRY GROUP™

NIST
National Institute of Standards and Technology
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# MEMS Testing Standards: A Path to Continued Innovation

## Report on MEMS Testing Standards Workshop

*MEMS Industry Group (MIG) partnered with National Institute of Standards and Technology (NIST) to identify and document device level qualification and testing needs and the results are published herein as a guide to where to focus R&D and standards development for device testing.*

# EXECUTIVE SUMMARY

Microelectromechanical systems (MEMS) have become a key enabling technology for many of today's high-technology products. But it is the promise of MEMS supporting new breakthroughs in areas such as green energy and radical medical innovations that makes the MEMS industry a key for the fate of US advanced manufacturing as well as for the jobs, innovations and numerous applications (including defense) that MEMS have already enabled.

But the promise of MEMS is at risk. It has been recognized for some time that the "back end" of MEMS production has been hindering the ability of the "front end" to realize the innovative potential of MEMS. In short, a lack of testing standards is increasing the time and costs of MEMS innovation with percentage of testing being between 20 and 50% of the cost of the device, often with the most complex and promising devices having the highest test costs. In effect there has been a market failure to standardize MEMS testing whose impact is only increasing as a direct function to advances in MEMS innovation. Fortunately, MEMS companies, large and small, have recently recognized that MEMS testing is, in fact, a pre-competitive place in the value chain, where cooperation would benefit all competitors and customers.

## VALUE PROPOSITION FOR INDUSTRY

Despite the known costs of testing, the MEMS industry has been slow to remedy the problem, in part due to concerns about Intellectual Property. But as testing costs have continued to rise as MEMS have become more sophisticated, recognition has developed that industry cooperation may be the only way to bring down the direct and indirect costs of testing. That is, industry has realized that cooperation in the non-value-add back-end processes of testing is pre-competitive, so by cooperating there companies can focus competition where it should be, at the front-end of innovation and meeting the needs of the market. Further, by cooperating, the costs associated with standardization can be spread over many companies. With industry taking the lead, government may be encouraged to lend further support.

In fact, the workshops recently hosted by MIG and NIST have shown a broad consensus that improved standards in testing would:

- Reduce labor input to testing
- Decrease the costs of test machines
- Reduce costs of training testing personnel
- Encourage greater availability and capability of test machines
- Reduce time to market
- Decrease re-testing at different levels of the supply chain
- Reduce requests by customers for unnecessary or unique tests

In addition, there are considerable potential indirect cost reductions and improvements in business practices to:

- Increase speed of innovation
- Expand the growth of the MEMS industry
- Simplify production processes
- Encourage new business models and relationships
- Reduce friction at handoff points that slow acceptance
- Create the foundation for better design software

## VALUE PROPOSITION FOR GOVERNMENT

In addition to the direct role that MEMS has in contributing to jobs, innovation and defense, the role of MEMS in the advanced manufacturing value chain also extends over time. MEMS are a key bridge between existing Integrated Circuit (IC) production and future nanotechnology. As Moore's law plays out, MEMS offers a "More than Moore" solution that will reduce much of the existing physical and intellectual infrastructure of IC development and production, as well as the IC centers of innovation (clustering). MEMS also serve as a bridge in size between the real world and nanoscale devices and will therefore be a key enabling technology for nano innovation.

Other countries have recognized this as evidenced by their creation of government, academic and business consortia to support MEMS innovation. Such countries include as Canada, France, Malaysia, Japan, South Korea, Singapore and China. These represent threats at the low and high end of the market. Lowering testing costs would reduce the incentives to outsource to low end countries and providing standards might give US test equipment manufacturers and software design houses a competitive edge over high end countries. Perhaps more significantly, many emerging countries have placed MEMS into the national industrial policy roadmaps as an area for strategic investments. That is, the US must take steps to continue to maintain its global position to maintain jobs and innovation.

So although the industry (both large and small players) has recognized that this marker failure is in a pre-competitive portion of the value chain, it is unlikely the industry can organize itself and support all

the required activities and investments without assistance support from the government – as demonstrated by the key role NIST has played thus far in the industry's efforts at cooperation.

For these reasons, the MEMS industry is good target for public private partnerships (PPPs). The recent PCAST "Report to the President on Ensuring American Leadership in Advanced Manufacturing," listed criteria for co-investing which the MEMS industry seems to fit well:

- The technology area has a high potential payoff in employment and output.
- There is a prospect of sustainable competitive advantage for the U.S., including through first-mover advantage.
- Identifiable market failures impede adequate private investment.
- PPPs include industrial partners who are willing to co-invest with the government.
- PPPs include some industrial partners with sufficient size to invest at scale in the fruits of the pre-commercial research, as well small and start-up enterprises.
- Investments will help anchor subsequent manufacturing in the United States—for example, through shared labs, pilot plants, technology infrastructure and creation of clusters.
- Shared infrastructure will help existing firms and industries compete globally by increasing the quality and performance of their products.

## INDUSTRY EFFORTS

MIG, with the support of NIST, organized a series of workshops, surveys and interviews with a broad swath of the MEMS industry to understand how to improve testing standards. These activities generated findings that are listed below and discussed in detail in the report that follows.

# EXECUTIVE SUMMARY

## Summary of Key Findings

- A lack of testing standards has a negative indirect effect on the business of MEMS at all level of the value chain.
- Testing imposes large direct costs on the industry.
- Ongoing changes in MEMS markets are going to increase testing problems.
- There are customer/manufacturer interface points that are "pre-competitive" in nature and therefore open to mutually beneficial cooperation.
- Baseline qualification guidelines may be the easiest target.
- A reasonable set of test standards already exist and are being used.
- The test methods for specifications in the data sheet are not well defined.
- Test equipment is not standardized and is expensive.
- Customer behavior increases testing challenges.
- NIST and MIG are the appropriate organizations to drive any effort at MEMS test standardization.
- Wafer level testing is significantly harder for MEMS than CMOS with only a 20% commonality.
- Device level testing is the right place to start standardization efforts.
- Inertial sensors are the right device category.
- Design for Test (DFT) is an important, but aspirational goal.

From these findings, a series of workshop participants formulated a series of recommendations to be shared with the larger MEMS community and relevant government officials. These recommendations are designed to have the highest impact on the industry with the lowest risk of failure.

In addition, they are meant to be a foundation on which to build further cooperation. Though the scope of this proposed effort is narrow in order to increase the chances of success, it will lay a foundation to support other precompetitive areas such as improved design software and possibly process standardization.

## Summary of Recommendations

- Define standards for the specifications in the data sheet.
- Promote the establishment of a University MEMS Test Center of Excellence to advance research in testing and that links industrial mentors with graduate students.
- Work collaboratively with customers and other related organizations.
- Improve qualification/characterization methods for test equipment.
- Begin efforts at wafer-level test standards, with the understanding that this will be harder than device level testing.
- Support efforts for easier Design for Test (DFT) capability.

The final recommendation was for MIG and NIST to move forward to implement the recommendations with an action plan.

## Summary of Action Plan

- MIG will confirm these recommendations with its governing council and technical advisory committee (TAC).
- MIG will consider asking NIST for expanded support as a next step in this initiative.
- NIST will continue its roadmapping activities.
- NIST will work with MIG members to begin implementation of data sheet standards.
- NIST will work to advance measurement science for accelerated reliability testing.
- Efforts will be made by all parties to enlist other government agencies to support these activities.

This report documents these industry efforts to standardize testing. It also presents an action plan for success using MIG as the forum for cooperation with the support of NIST as well as possibly other government agencies. As a way of context, the report also discusses the MEMS market, describes MEMS innovations and outlines the importance of MEMS to US job growth and innovation.

# EXECUTIVE SUMMARY

Many have contributed to this report and the activities that have led to it.

**MIG Testing Standards Steering Committee:**

**NIST**

- Herbert Bennett, Ph.D., NIST Fellow and Executive Advisor
- Michael Gaitan, Ph.D., Group Leader
- Yaw Obeng, Ph.D., Senior Scientist

**MIG Staff**

- Karen Lightman, Managing Director
- Monica Takacs, Director of Programs and Marketing

Report preparation and other support

- Eric Levy-Myers
- Mario Correa, Diablo Design + Test

And special thanks to all those who participated in the survey and workshops and are listed in the appendix

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# MEMBERS OF MIG (AS OF SEPTEMBER 9, 2011)

| | | |
|---|---|---|
| Acuity Incorporated | ACUTRONIC | AEPI Grenoble-Isere France Economic Development Agency |
| Akrion Systems | Akustica | All Sensors |
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| HP | IceMos Technology, Ltd | imec |
| Innovative Micro Technology IMT | innovoSource | Institute of Microelectronics |
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| MEMS Foundry Itzehoe GmbH | MEMS Vision | MEMSCAP |
| memsstar | MEMStaff | Micralyne |
| MicroGen Systems | MicroVision | Midwest MicroDevices |
| Movea | Nanoshift LLC | NIST |
| Nokia | OAI | OEM Group |
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| Plan Optik AG | Plasma-Therm | Plures Technologies |
| Polytec | Potomac Photonics | Radant MEMS |
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| SoftMEMS | SPTS Technologies | STMicroelectronics |
| SUSS Microtec | SVTC | Tecnisco |
| Teledyne DALSA | Texas Instruments | Touch Micro-system Technology |
| Tronics Microsystems | VirtualFabs, Inc. | VTI Technologies |
| Wispry | XACTIX | Xsens Technologies |
| Yield Engineering Systems | | |

## Industry Partners

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| ABI Research | A*STAR | Fab Owners Association |
| Globalpress Connection Inc. | Global Semiconductor Alliance | iNEMI |
| iSuppli | IVAM | Eric Levy-Myers, Consultant |
| MEMS and Nanotechnology Exchange | MEMS Investor Journal | MEMS Park Consortium |
| MEPTEC | Micromachine Center | Nano Science and Technology Institute (NSTI) |
| Rapid News Communications Group | SEMI | Sensors Expo |
| Small Times | Yole Développement | |

# EXECUTIVE SUMMARY

**MIG Steering Committee – MEMS Testing Standards**

1. Sandeep Akkaraju, IntelliSense
2. Tim Barnes, Okmetic
3. Steve Becka, Honeywell
4. Roc Blumenthal, SVTC Technologies
5. Ken Brizel, ACAMP
6. Joe Brown, MEMS and Nanotechnology Exchange
7. Dave Busch, SVTC Technologies
8. Troy Chase, Akustica, Inc. A Subsidiary of Bosch
9. Matt Commens, ANSYS, Inc.
10. John Ellis, SEMI
*11. Michael Gaitan, NIST
12. Steve Grady, Cymbet Corporation
*13. Buzz Hardy, MEMSCAP
14. Howard Havlicsek, ACUTRONIC USA
15. Jeff Hawks, EV Group
*16. Alissa Fitzgerald, AM Fitzgerald and Associates
17. Gavin Ho, Gavin K Ho
18. Sandy Hu, Asia Pacific Microsystems
19. Nicole Kerness, Maxim Integrated Products, Inc.
20. Dave Kirsch, EV Group
*21. Karen Lightman, MEMS Industry Group
22. Pinyen Lin, Pinyen Lin
23.David Lishan, PlasmaTherm
24. Patrick Long, Maxim Integrated Products, Inc.
25. Nick Lycoudes, Freescale Semiconductor
26. Tony McKie, memsstar
27. J. Jay McMahon, General Electric (GE)
28. Calin Miclaus, General Electric (GE)
*29. Mike Mignardi, Texas Instruments
30. Christopher Milne, Honeywell
31. Tom Morrow, SEMI
32. Matan Naftali, Maradin Technologies Ltd.
33.Gary O'Brien, Robert Bosch Corporation
34. Jaime Olivas, ACUTRONIC USA
35. Robert O'Reilly, Analog Devices
*36. Sascha Revel, ACUTRONIC USA
37. Magnus Rimskog , Silex Microsystems
38. Mike Rosa, Applied Materials, Inc.
39. Andre Rouzaud, CEA-Leti
*40. Dominique Schinabeck, ACUTRONIC USA
41. Brian Stephenson, Tronics Microsystems
42. Jason Tauscher, MicroVision
43. Markku Tilli, Okmetic
44. Paul Trio, SEMI
*45 Rob O'Reilly Analog Devices
46. Steve Wilcenski, MEMSCAP
47. Brian Wirth, General Electric (GE)
48. Bin Wu, Freescale Semiconductor
49.Gary Yama, Robert Bosch Corporation
*50. Jim Knutti, Acuity
51. Dawn Hilken, AM Fitzgerald and Associates
*52. Richard Allen, NIST

* Core Team of Steering Committee

# PARTICIPANTS IN CONFERENCE ACTIVITIES

## IEEE Meeting Participants

| | |
|---|---|
| Sormunen, Jaakko | Okmetic |
| Oita, Takeo | Nihon Dempa Kogyo Co., Ltd. |
| Jung, Thomas | ACUTRONIC USA |
| Pabo, Eric | EV Group |
| Breit, Stephen | Coventor |
| Clark, Jeff | Silex Microsystems |
| Rimskog , Magnus | Silex Microsystems |
| Cases, Sebastien | SoftMEMS |
| Tousimis, Yianni | Tousimis Research Corporation |
| Huang, Qing-An | Southeast University |
| Ramirez Venta, Martin | n/a |
| Pineda, Mario | Polytec |
| Stoffel, Nancy | STC MEMS |
| Peroulis, Dimitrious | Purdue University |
| Beijerinck, Herman | Eindhoven University of Technology |
| Reed, Jim | Okmetic |
| Seki, Tomonori | OMRON Corporation |
| Bounouh, Alexandre | LNE-National metrology laboratory France |
| Wang, Lei | Southest University - Nanjing, China |
| Fujita, Hiroyuki | University of Tokyo |

## Workshop Participants

| | | |
|---|---|---|
| Richard Allen, NIST | Chris Apanius, Promerus | Mehdi Attaran, Johnstech International |
| Wilfried Bauer, Polytec GmbH | Herbert Bennett, NIST | Peter Binkhoff, ELMOS/SMI |
| Monalisa Bora, Mentor Graphics | Kevin Chau, MEMStaff | Edward (Chen-Wei) Chiu, Asia Pacific Microsystems |
| Hubert Dinh, SMI | Alissa Fitzgerald, AM Fitzgerald & Associates | Bruno FLAMENT, MOVEA |
| Tom Flynn, Coventor | Michael Gaitan, NIST | Gavin Ho, MEMStaff |
| Kenneth Johnson, M Cubed, Inc. | Johannes Kade, Fraunhofer IPMS | Nicole Kerness, Maxim Integrated Products, Inc. |
| Jim Knutti, Acuity Incorporated | Eric Lawrence, Polytec GmbH | Eric Levy-Myers |
| Jinshan Li, Western Digital | Karen Lightman, MEMS Industry Group | Qing Ma, Intel |
| Mary Ann Maher, SoftMEMS | Mike Mignardi, Texas Instruments | Kevin Nason, Fairchild Semiconductor |
| Yaw Obeng, NIST | Gary O'Brien, Robert Bosch Corporation | Robert O'Reilly. Analog Devices |
| Petteri Piirinen, Okmetic | Sascha Revel, ACUTRONIC USA | Magnus Rimskog, Silex Microsystems |
| Pete Sandow, Okmetic | Jeff Sather, Cymbet Corporation | Monica Takacs, MEMS Industry Group |
| Paul Trio, SEMI North America | Maarten Vraanes, MEMS Investor Journal | Nathan Waissman, Freescale Semiconductor |
| Kacey Wherley, MEMS Industry Group | Carolyn White, A M Fitzgerald and Associates | Muthu Wijesundara, ARRI/ UTA |
| Steve Wilcenski, MEMSCAP | | |

## M2M Forum Participants

Richard Allen, NIST
Chris Apanius, Promerus
Wilfried Bauer, Polytec GmbH
Herbert Bennett, NIST
Edward (Chen-Wei) Chiu, Asia Pacific Microsystems
Tom Di Stefano, Centipede Systems
Bruno FLAMENT, MOVEA
Michael Gaitan, NIST
Johannes Kade, Fraunhofer IPMS
CT Kao, A M Fitzgerald and Associates
Nicole Kerness, Maxim Integrated Products, Inc.
Jim Knutti, Acuity Incorporated
Eric Lautenschlager, Knowles Acoustics
Eric Lawrence, Polytec GmbH
Kenneth Johnson, M Cubed, Inc.
Kyle Lebouitz, XACTIX, Inc.
Eric Levy-Myers
Karen Lightman, MEMS Industry Group
Jennifer MacDonell, Meggitt Sensing Systems
Mary Ann Maher, SoftMEMS
Professor Mehran Mehregany, Case School of Engineering,
Mike Mignardi, Texas Instruments
Garrett Oakes, EV Group
Yaw Obeng, NIST
Gary O'Brien, Robert Bosch Corporation
Robert O'Reilly, Analog Devices
Petteri Piirinen, Okmetic
Sascha Revel, ACUTRONIC USA
Magnus Rimskog, Silex Microsystems
Jeff Sather, Cymbet Corporation
Monica Takacs, MEMS Industry Group
Tian Tang, EV Group
Paul Trio, SEMI North America
Maarten Vraanes, MEMS Investor Journal
Nathan Waissman, Freescale Semiconductor
Kacey Wherley, MEMS Industry Group
Carolyn White, A M Fitzgerald and Associates
Muthu Wijesundara, ARRI/ UTA
Steve Wilcenski, MEMSCAP

# CONTACT INFO

**MEMS Industry Group**
1620 Murray Ave.
Pittsburgh, PA 15217
Phone: 412-390-1644
Fax: 412-381-7714
www.memsindustrygroup.org
info@memsindustrygroup.org

Karen Lightman, Managing Director – klightman@memsindustrygroup.org
Monica Takacs, Director of Programs and Marketing – mtakacs@memsindustrygroup.org

**NIST**
100 Bureau Drive
Gaithersburg, MD 20899-1070
Phone: (301) 975-NIST
www.nist.gov

Michael Gaitan, Ph.D., Group Leader – Gaitan@nist.gov