Bridging the Gap from Lab to Fab

MEMS Industry Group
Karen Lightman
Managing Director

www.memsindustrygroup.org
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My Presentation Today

- Overview of MEMS Industry Group (MIG)
- Overview of MEMS industry
- Setting the stage for today’s program on crossing the chasm from lab to fab and on maximizing MEMS commercialization
MEMS Industry Group (MIG) – Introduction

- Formed in 2001 with five companies - as outgrowth of MEMS industry executive meetings at DARPA
- Industry trade association incorporated as a not-for-profit organization, based in Pittsburgh
- Managed by a Managing Director, Karen Lightman, under aegis of Governing Council composed of representatives from member companies
- Nearly 100 member companies – from start-ups to Fortune 500 companies, MIG members ARE the entire MEMS supply chain:
  - Device manufacturers, equipment suppliers, materials suppliers, foundries, software vendors, partners, market analysts...

MIG Mission Statement

MEMS Industry Group (MIG) is THE leading trade association advancing MEMS across global markets. We are the global MEMS supply chain.

MIG’s approach:
- Enables the exchanging of non-proprietary information among members;
- Provides access to reliable industry data that furthers the development of technology; and
- Promotes greater commercial development and use of MEMS and MEMS-enabled devices.
MEMS Industry Group Members

Acutronic USA
EPI Grenoble-Isere France Economic Development Agency
A.E. Fitzgerald & Associates
Amerimade Technology
Applied Materials
Analog Devices
ASYS
Asian Pacific Microsystems
Automation & Robotics Research Institute (ARRI)
Avago Technologies
Baolab Microsystems
Bosch RTC
Brewer Science
Bullen Ultrasounds
Clement Lo Consulting
Coventor, Inc.
Cymbet
DALSA Semiconductor
DalMEMS
Dharris Group
Discera
Draper Laboratory
Endevo MEMS
EPCOS Netherlands
Eric Levy-Myers

EV Group
Fraunhofer ENAS
Fraunhofer IPMS
Freescale Semiconductor
Fullpower Technologies, Inc.
GE Global Research & GE Sensing
Gavin Ho – Consultant
Global Foundries
Honeywell
IMEC
Innovative Micro Technology (IMT)
Institute of Microelectronics (IME)
Intel Corporation
InvenSense
Istupli
IVAM
Kilbrydon Consulting
Kionix
Knowles Acoustics
Lam Research Corporation
Leti
Maradin Technologies Ltd.
Maxim Integrated Products
MEI LLC
MEMSCAP
MEMS Exchange
MEMS Foundry Itzehoe GmbH
MEMStaff Inc.
memstar
MEPTEC
Micralyne, Inc.
MicroGas Systems
Micromachining Center

Microvision
Midwest Micro Devices
Nanosight
NIST
Northrop Grumman
Oekomet Oyj
Omron
Optical Associates Inc
Pinyen Lin
Plasma-Therm LLC
Plan Optik AG
Primea, Inc.
Proteus Biomedical
Radiant MEMS
Sand9
SEMI
Semiconductor Support Services Co.
SensaNor
Silex Microsystems
Small Times
SoMEMS
SPP Process Technology Systems (SPTS)
SVTC Technologies
Tekton Consulting, LLC
Texas Instruments
Thai Nguyen
TRONICS
VTI Technologies, Inc.
Xactix
Wispry, Inc.
Yole Développement

MIG Programs and Benefits

MIG offers a wide range of programs for everyone in your company – from the top executive to the new hire:

- Annual Members Meeting (technical and business-focused)
- MEMS Executive Congress (business-focused)
- MEMS Education Series – webinars and online meetings (education)
- Projects led by steering committees (MEMS testing standards, foundry guidelines,...)
- MEMS Marketplace
- Resources
  - MEMS Packaging Glossary
  - White Papers
  - Industry Data
  - Presentations
- Membership Directory
- Introductions
- PR and Information sharing and dissemination through blogs, Twitter, LinkedIn, YouTube, and newsletters

These programs provide a forum for:

- Overcoming technical challenges in MEMS
- Idea exchange and collaboration
- Networking
- Professional education
- Company promotion (to other companies and to the media)
Keynote Speakers:
- Rich Duncombe, Distinguished Technologist, Hewlett-Packard Company
- Vida Ilderem, Vice President, Intel Labs, Director, Integrated Platform Research Lab, Intel Corporation

Panels
- MEMS Market Analyst Panel
- Smart and Clean Energy
- Robotics and Intelligent Healthcare Products
- Next-Generation Mobile and Consumer MEMS

A very special thanks to our sponsors!

Total MEMS Market by Application

High Value Markets
- Wind Communications
- Aerospace, Defense, Security
- Medical Electronics
- Industry and Process Control
- Data Processing
- Automotive
- Mobile and Consumer Electronics

Source: iSuppli Corporation MEMS Market Tracker H1 2010
The MEMS Supply Chain Size 2008–2012

- **MEMS-based systems**
  - US$46B → US$83B

- **MEMS devices**
  - US$6.94B → US$12.4B

- **Equipment**
  - US$142M → US$510M

- **Materials & chemicals**
  - US$89M → US$220M → US$321M
  - for substrates & photomasks
  - US$149M for chemicals (wet, gas...)

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7 Different MEMS Business Models*

- **Business Models**
  - Component manufacturers
  - Design companies
  - System manufacturers

- **Component manufacturers**
  - Foundries: Dalsa, APM, TMT, Neostones

- **Design companies**
  - Integrated Fab: HP, Bosch, Honeywell, GE...
  - Engineering & design

- **System manufacturers**
  - Fabless

- **Contract manufacturers**
  - Colbrys, Micralyne, Tronics, MEMSCAP, Silex...

- **Off-the-shelf MEMS components**
  - ADI, ST, Freescale...

- **External MEMS Fab with internal R&D** [GE...]

* JC Eloy, Yole Development
MEMS Players
Breakdown of MEMS Business Model by Area

<table>
<thead>
<tr>
<th></th>
<th>Asia</th>
<th>Europe</th>
<th>US</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fab</td>
<td>65%</td>
<td>43%</td>
<td>47%</td>
<td>24%</td>
</tr>
<tr>
<td>Foundry</td>
<td>9%</td>
<td>5%</td>
<td>8%</td>
<td>6%</td>
</tr>
<tr>
<td>Fabless</td>
<td>4%</td>
<td>25%</td>
<td>29%</td>
<td>6%</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>22%</td>
<td>27%</td>
<td>16%</td>
<td>65%</td>
</tr>
</tbody>
</table>

MEMS Products are in the Development Phase
Having Successfully Crossed the “Chasm”

Emerging MEMS Definition

- Inkjet Head
- Filters
- MEMS IO
- MEMS Speakers
- Microbolometers
- Microstructures
- Microphones
- Oscillators
- MEMS
- Pressure sensors
- Gyroscopes
- Accelerometers
- Electronic Compass
- Microdisplay
- Autofocus/µZoom
- Energy harvesting
- µFuel cells
New MEMS Devices are Reaching Maturity Faster and Faster...

<table>
<thead>
<tr>
<th>Company</th>
<th>Product and application</th>
<th>R&amp;D duration from first R&amp;D work to first production in the company</th>
<th>Time to reach 300 Munits shipped</th>
<th>Estimated cumulated sales for the first 300 Munits (US$ M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freescale</td>
<td>Accelerometer for automotive and industrial applications</td>
<td>8 years</td>
<td>13 years</td>
<td>1 000</td>
</tr>
<tr>
<td>Avago Technologies</td>
<td>FBAR for RF front end module for mobile phone</td>
<td>6 years</td>
<td>5 years</td>
<td>210</td>
</tr>
<tr>
<td>Knowles Acoustics</td>
<td>Microphone for consumer markets</td>
<td>15 years</td>
<td>4 years</td>
<td>150</td>
</tr>
<tr>
<td>SiTime, Discera</td>
<td>MEMS based oscillator</td>
<td>3 years</td>
<td>2 years (Yole est.)</td>
<td>150 (Yole est.)</td>
</tr>
<tr>
<td>InvenSense</td>
<td>2 axis gyroscope</td>
<td>2 years</td>
<td>4 years (Yole est.)</td>
<td>400 (Yole est.)</td>
</tr>
<tr>
<td>Siimple, Varioptic</td>
<td>MEMS based autofocus for consumer applications</td>
<td>3 years</td>
<td>4 years (Yole est.)</td>
<td>400 (Yole est.)</td>
</tr>
<tr>
<td>Infineon, GE Sensing...</td>
<td>Tire pressure monitoring</td>
<td>5 years</td>
<td>7 years (Yole est.)</td>
<td>750 (Yole est.)</td>
</tr>
</tbody>
</table>

Show me the Money

- Big issues remain – to fuel the entrepreneurship and technology advancement:
  - Where’s the R&D? Who is really innovating and commercializing (not mutually exclusive)?
  - Where’s the venture capital and investment?
  - White House Office of Science and Technology (OST) interested in MEMS as growth engine…what can we “teach” them?

- How to better encourage innovation transfer?
  - What can the MEMS industry learn from other similar industries?
    - Innovation communities, innovation networks...
Several unique models for further commercialization of technology in US:
- University/industry partnership (BSAC)
- VC-funded initiatives
- Academic/corporate model
- Government funding – DARPA and now ARPA–E
- Large integrated corporate models – GE Global Research

Fabless is fabulous – growing trend in MEMS
- Rise of fabless and fab–lite; shared fab model

What can we learn from each model and how does it relate to the MEMS industry?

8.5 Different MEMS Business Models*

*JC Eloy, Yole Developpement
MEMS Success Factors at GE*

*Strong culture of applied R&D
*“High impact” discovery process
*Systems engineering expertise
*Research Center MEMS capabilities

GE Model – Low Volume with High Revenue*

*Bill Hawkins, GE Global Research
MEMS features can greatly increase revenue and gross margin

**MEMS Killer App’s – Redefined**

<table>
<thead>
<tr>
<th>Market</th>
<th>Placements</th>
<th>Revenue</th>
<th>Delta</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Units</td>
<td>$ B</td>
<td>$ M</td>
</tr>
<tr>
<td>CT</td>
<td>3800</td>
<td>$ 3.8</td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>5000</td>
<td>$ 10.0</td>
<td></td>
</tr>
<tr>
<td>MRI</td>
<td>3700</td>
<td>$ 3.7</td>
<td></td>
</tr>
<tr>
<td>Digital x-ray</td>
<td>17500</td>
<td>$ 3.5</td>
<td></td>
</tr>
<tr>
<td>&quot;Example market&quot;</td>
<td>7500</td>
<td>$ 5.3</td>
<td></td>
</tr>
<tr>
<td>1/3 market share</td>
<td>2500</td>
<td>$ 1.8</td>
<td></td>
</tr>
<tr>
<td>Improve 5% &amp; 5%</td>
<td>2625</td>
<td>$ 1.9</td>
<td>$ 179</td>
</tr>
<tr>
<td>Improve 10% &amp; 10%</td>
<td>2750</td>
<td>$ 2.1</td>
<td>$ 368</td>
</tr>
</tbody>
</table>

MEMS industry maturing – the “S” word – testing standards and protocols...

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**Conclusions**

- **High-volume manufacturing is NOT the only way to maximize growth:**
  - There are several high-value, specialized MEMS (industrial, defense, medical)
    - True opportunity is in what MEMS enables – the algorithm/science behind the device
    - Fabless is fabulous – innovative MEMS companies supported by fabs that are getting more adept at MEMS manufacturing & integration
    - There have been great changes in MEMS – we’ll likely see more consolidation and partnership in the next five years...

- **Cost is critical factor BUT:**
  - With increase in technology and algorithms enabled by MEMS, more “system sell” – see Apple iPhone and proliferation of apps enabled by MEMS
  - We’ll see more on-chip integration, CMOS, TSV and other fabrication techniques to enhance functionality AND reduce costs
  - MEMS industry maturing – the “S” word – testing standards and protocols...
Thank you!

MEMS Industry Group
www.memsindustrygroup.org
1620 Murray Avenue
Pittsburgh, PA 15217
info@memsindustrygroup.org
PH: 412.390.1644