### Past Meetings

<table>
<thead>
<tr>
<th>Date</th>
<th>Title</th>
<th>Guests</th>
<th>IEEE</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 22nd</td>
<td>Emerging Trillion Sensors Movement (Dr. Janusz Bryzek)</td>
<td>39</td>
<td>41</td>
<td>80</td>
</tr>
<tr>
<td>Feb. 26th</td>
<td>FBAR and FMOS Technology from a MEMS Perspective (Dr. Stephen Gilbert)</td>
<td>35</td>
<td>35</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Advanced Metal Eutectic Bonding for High Volume MEMS (Sumant Sood)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mar. 18th</td>
<td>Coupled-Filed MEMS Simulations (Dr. Metin Ozen)</td>
<td>25</td>
<td>7</td>
<td>32</td>
</tr>
<tr>
<td>April 30th</td>
<td>MEMS Wars: A New Hope (Dr. Kurt Petersen)</td>
<td>37</td>
<td>39</td>
<td>76</td>
</tr>
<tr>
<td>May 28th</td>
<td>MEMS in SEMI – The Role of a Global Association in Advancing the MEMS Industry (Bettina Weiss)</td>
<td>11</td>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>June 25th</td>
<td>MEMS on Alternate Substrates: A Case Study with Biometric Sensors (Dr. KG Ganapathi)</td>
<td>21</td>
<td>29</td>
<td>50</td>
</tr>
<tr>
<td>July 23rd</td>
<td>AdCom/Volunteers meeting</td>
<td>11</td>
<td>10</td>
<td>21</td>
</tr>
<tr>
<td>Aug. 27th</td>
<td>RF MEMS: From Research to Products (Prof. Gabriel Rebeiz)</td>
<td>30</td>
<td>46</td>
<td>76</td>
</tr>
<tr>
<td>Sept. 24th</td>
<td>IEEE MEMS Happy Hour (No invited talk).</td>
<td>12</td>
<td>12</td>
<td>24</td>
</tr>
<tr>
<td>Oct. 22nd</td>
<td>MEMS-enabled microscopes for in-vivo studies of cancer biology</td>
<td>29</td>
<td>31</td>
<td>60</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>250</td>
<td>262</td>
<td>512</td>
</tr>
</tbody>
</table>
The MEMS and Sensors Chapter is run by volunteers organized as Officers (elected every year), Program Committee, and Advisory Board. If you are interested in volunteering, please send an email to SFBA-MEMS-OFFICERS@listserv.ieee.org.

**Officers:**
*Chair:* Dr. Ramesh Ramadoss, Senior Manager, FormFactor Inc.
*Vice-Chair:* Dr. Yan Du, Manager, Qualcomm MEMS Technologies Inc.
*Secretary:* Dr. Gavin Ho, President, NanoFab Corp.
*Treasurer:* Mr. Jeremie Dalton, Staff Engineer, Enovix Inc.
*Workshop Chair:* Mr. Brent Lunceford, Advanced Product Development, 3M.

**Program Committee:**
Dr. John Lee, Associate Professor, Mechanical Engineering, San José State University
Dr. Mary Ann Maher, President, SoftMEMS Inc.
Dr. Nisarga Naik, Research Scientist, Intel Labs.
Dr. Hojr Sedaghat-Pisheh, Hardware Engineer/Manager, Google Inc.
Mr. Sumant Sood, Product Marketing Manager, KLA-Tencor Inc.
Amber Sun, Senior Engineer, Qualcomm Inc.
Dr. Youmin Wang, Postdoc, UC Berkeley.
Dr. Ernest Yen, MEMS Researcher, Texas Instruments Inc.
Dr. Ningning Zhou, Staff Engineer, Qualcomm MEMS Technologies.

**Advisory Board:**
Dr. Janusz Bryzek, TSensors Summit.
Mr. Gene Burk, Consultant, IMT Inc.
Dr. Leslie Field, Founder, SmallTech Consulting LLC; Consulting Professor, EE, Stanford University.
Dr. Jim Knutti, President/CEO, Acuity Inc.
Dr. Kurt Petersen, President, KP-MEMS Inc.
Complimentary food and refreshments sponsored by SoftMEMS Inc.

Thanks to Dr. Mary Ann Maher, President/CEO
Upcoming Meetings

Feb. 25th, 2015 (Wednesday) 7:45 PM to 8:45 PM. Note: NEW LOCATION!!!
Title: Building Successful MEMS Company: From Start to IPO
Speaker: Mr. Steve Nasiri, Nasiri Ventures
Location: Texas Instruments Building E Conference Center, 2900 Semiconductor Dr., Santa Clara, CA 95052 (Directions)
Food: Pizza and beverages will be available at 7:15 pm for a $5 donation at the door.
Sponsor: Sponsorship opportunities are available. Interested parties please email SFBA-MEMS-OFFICERS@listserv.ieee.org

Mar. 25th, 2015 (Wednesday) 5:30 PM to 7:30 PM. Online registration coming soon.
IEEE MEMS and Sensors Happy Hour
Location: Steelhead Brewing Company, 333 California Drive, Burlingame, CA 94010
This is a no-host event. Please pay for your own food and drinks.
Sponsor: Sponsorship opportunities are available. Interested parties please email SFBA-MEMS-OFFICERS@listserv.ieee.org
Invited talk by Mr. Holger Doering

Nov. 19th, 2014 (Wednesday) 7:45 PM to 8:45 PM.
Title: Innovative Pressure Sensing Solutions.
Speaker: Mr. Holger Doering, COO, Silicon Microstructures, Inc.

Holger Doering is the Chief Operating Officer (COO) at Silicon Microstructures Inc (SMI). He joined SMI in 2007 as a Consultant in Operations, then took over the VP Operations position in 2008 and was promoted to COO in 2011.

He is responsible for Production, Process Engineering, IT, Assembly, Test, and Facilities Management. He started at ELMOS in 1995 as a Process Engineer and became Production Engineering Manager in 1997. From 1999 he was responsible for Production, Process Engineering and Equipment Maintenance in the Plasma-Module of the ELMOS fab. In 2003 he began to transfer the 0.8 μm process from the 6-inch fab in Dortmund to the 8-inch line of the joint ELMOS/ Fraunhofer IMS fab in Duisburg and in 2005 became responsible for the complete 8-inch Operations in Duisburg.

Holger holds a diploma in Electrical Engineering from the University of Dortmund (Germany) with a focus on semiconductor manufacturing. His diploma thesis work was carried out at ELMOS in 1994 where he developed a CMOS-compatible process module to produce monolithic integrated piezoresistive pressure sensors in a EU-funded project.
Abstract: Silicon Microstructures Inc (SMI) is a premier semiconductor sensor company developing and manufacturing MEMS-based pressure sensors for automotive, medical, and industrial markets. It has a long history rooted in Silicon Valley since 1991. This talk will present the recent developments in pressure sensor R&D and production at SMI. It will cover the following aspects:
1. Company overview on products, R&D and Manufacturing capabilities
2. DRIE etch is essential for pressure sensor miniaturization. This talk will present SMI ultra-small pressure sensor development with DRIE process.
3. Automated Optical Inspection (AOI) for defect detection in MEMS devices. This talk will cover the application criteria and inspection capabilities.
Innovative Pressure Sensing Solutions

Created by Dr. Shaoxin Lu, Abhishek Davray, Raul Figueroa and Holger Doering

November 18, 2014

Supporting customer success in Automotive, Medical and Industrial markets since 1991
Enabling our customers’ success in improving health, safety, and the environment by providing creative pressure sensing solutions leveraging our leading MEMS technology.
1) SMI Company Overview

2) DRIE Etch for MEMS pressure sensor miniaturization

3) Automated Optical Inspection (AOI) for defect detection in MEMS Devices
Content

1) SMI Company Overview

2) DRIE Etch for MEMS pressure sensor miniaturization

3) Automated Optical Inspection (AOI) for defect detection in MEMS Devices
Leader in MEMS-based Pressure Sensing Solutions

- **Lowest pressure**: down to 4 mbar range (1.5” H₂O)
- **Media Resistant**: noble metallization w/ backside entry.
- **Smallest size**: down to 0.9 mm × 0.25 mm × 75 µm

23 years of development and manufacturing expertise

- 100% subsidiary of Elmos Semiconductor AG (Germany)
- More than **500M sensors sold** into Automotive, Medical, Consumer, HVAC and Industrial markets

Captive Wafer Fab in Silicon Valley (USA)

All functions in one location:
- R&D, Process Development
- Logistics & Quality Control
Company History

1991  Founded in Fremont (CA)
2001  Acquired by elmos in Dortmund (Germany)
2002  Acquisition of MEMS fab, relocation to Milpitas (CA)
2004  Start of 6” MEMS production.
2006  TS16949 Certification
2007  SO-8 package platform
2012  Die Portfolio Refresh
2013  New Product Introductions SM9541
2014  New Product Introductions SM68E
Superior Quality and Long-Term Supply

ISO/TS 16949:2009 (Automotive)
ISO 9001:2008
ISO 14001:2004 (Environmental)

Frontend Processes
- Foundry: Create electrical components
- Etch Plant: Create mechanical components

Backend Processes
- Die Plant: • Final probe • Singulation • Inspection
- Packaging: Housing of pressure sensor and ASIC
- Test: • Calibration & compensation • Final test

State of the Art MEMS Manufacturing
Fully Equipped Wafer Fab
# Product Overview - Areas of Expertise

<table>
<thead>
<tr>
<th>Low Pressure</th>
<th>Typical Applications:</th>
<th>Low Pressure Sensor: 4 mbar SMI patented Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medical (CPAP), Industrial (HVAC)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ultra Small</th>
<th>Typical Applications:</th>
<th>Ultra-Small Die and Packaged Sensor for OEM Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Automotive (TPMS), Industrial (Barometric)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Harsh Environment</th>
<th>Typical Applications:</th>
<th>Harsh Environment Pressure Sensor Die</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Automotive transmission, Diesel Particle Filter (DPF) Exhaust Gas Recirc. (EGR)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signal-Conditioned</th>
<th>Typical Applications:</th>
<th>Dual Chip Intelligent Pressure Sensor, SO-16 Package</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Respiration Ventilators HVAC &amp; Pressure Transmitters</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Custom Design</th>
<th>Custom Pressure Sensor for Arterial Catheter:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.24 mm x 0.9 mm</td>
<td>(900 x 240 x 75 µm)</td>
</tr>
</tbody>
</table>
Markets and Applications

**Medical**
- Respiration
  - CPAP
  - Ventilation
- Hospital Beds
- Fluid Evacuation
- Blood Pressure
- Wound Therapy

**Industrial**
- HVAC
- VAV Controllers
- Pressure Transmitters
- Liquid Level & Pressure
- Barometric Pressure
- Process Control
- Refrigeration

**Automotive**
- Tire Pressure Monitoring Systems (TPMS)
- Manifold Air Pressure (MAP)
- Diesel Particulate Filter (DPF)
- Exhaust Gas Recirculation (EGR)
- Oil Pressure
- Side Air Bag
- Transmission Oil Pressure
- Seat Ergonomics
### Applications - Medical

#### Sleep Apnea Treatment

- CPAP (Continuos Positive Airway Pressure)
- Sleep disorder with abnormal pauses in breathing
- CPAP uses mild air pressure to keep an airway open
  - Feedback of applied air pressure in the mask
  - μC manages compressor to generate required pressure

#### Interventional Cardiology

FFR (Fractional Flow Reserve) guide-wire based procedure
  - accurately measure blood pressure and flow through a specific part of the coronary artery
  - assess whether or not to perform angioplasty and/or stenting on "intermediate" blockages.
  - FFR reduces procedure cost & increases success rate
  - Biocompatibility and blood as harsh environment
Applications - Industrial

Pressure Transmitters/HVAC

• HVAC (Heating, Venting, Air Conditioning)
• Differential pressure transmitters to detect over- / under- and differential pressure.

-> Monitoring and control of ventilation and air-conditioning, fans and filters.

-> requires measurement of very low-pressure signals

Valve Positioner

• Intelligent digital valve controllers
• Remote ambient pressure measurement

-> valve positioning & monitoring of supply pressure

-> support advances in building technology and energy efficiency mandates
Applications - Automotive

**Tire Pressure Monitoring Systems (TPMS)**
- Ultra small absolute pressure sensor for integration in tire inflation valve
- Legislation in USA (2007) requires all new cars to be equipped with TPMS.
- 2013 – Europe started with 100% compliance in 2014.
- 2014 – South Korea confirmed legislation.
- 2017 – Japan intends to legislate.
- 2018 – China intends to legislate.
- 2019 – India intends to legislate.

**Dual-clutch Automated Manual Gearbox**
- Backside entry absolute pressure sensor with harsh media compatibility
- Direct contact to hot transmission oil at high pressure in the application

New DSG (Direkt Schalt Getriebe) transmission offers
- better fuel economy
- extremely fast shift times
- no loss of torque during gear shifts
- Pressure sensors monitor correct operation.
Design & Simulation of Advanced Pressure Sensors

Finite Element Modeling
- Optimize structure and predict results
- Mechanical stress and strain
- Resistance and temperature

Process and Device Modeling
- Determine doping profiles from process
- Predict electrical characteristics of devices
- 2D device modeling

Design Rule Checking of Device Layout
- Verify placement tolerances of electrical components
- Check predicted distances between electrical and mechanical components of MEMS structures
Process Requirements of Advanced Pressure Sensors

- Double side polished wafer processing – defects on wafer backside from conventional handling arms

- Front to Back Alignment and Overlay / IR Measurement

- Stable micro machining technology:
  - Deep Reactive Ion Etching / KOH Etching using Electro Chemical Etch Stop
Content

1) SMICompany Overview

2) DRIE Etch for MEMS pressure sensor miniaturization

3) Automated Optical Inspection (AOI) for defect detection in MEMS Devices
DRIE – Deep Reactive Ion Etching

**Bosch Process**

- Silicon anisotropic etching based on etch/deposition cycle by cycling SF6/C4F8
- Silicon etch in SF6 cycle
- Passivation of sidewalls with polymer in C4F8 cycle
## DRIE vs KOH Etch

**Benefits for DRIE**

- Precise control of membrane thickness
- Area reduction for sensors
- Bigger mounting surface, no constraint wafer necessary
- Better accuracy / repeatability

<table>
<thead>
<tr>
<th></th>
<th>KOH</th>
<th>DRIE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Membrane Thickness</td>
<td>Controlled by Etch rate / Etch stop</td>
<td>Defined by SOI starting material</td>
</tr>
<tr>
<td>Sensor Size</td>
<td>Bigger (with sidewall slope)</td>
<td>Smaller (vertical sidewall)</td>
</tr>
<tr>
<td>Mounting Area (% of die)</td>
<td>Smaller (with sidewall slope)</td>
<td>Bigger (vertical sidewall)</td>
</tr>
<tr>
<td>Accuracy/Repeatability</td>
<td>Worse (TTV, Etch rate variation)</td>
<td>Better (SOI material control)</td>
</tr>
<tr>
<td>Cost</td>
<td>Less expensive</td>
<td>More expensive (factor 3 x variable cost)</td>
</tr>
<tr>
<td>Throughput</td>
<td>Batch process (factor 2 x faster than DRIE)</td>
<td>Single wafer process</td>
</tr>
</tbody>
</table>
Products at SMI that benefit from DRIE

- Ultra small pressure sensors (SM68) for TPMS applications:
  -> Pressure range from 15 - 150 psi
  -> DRIE formed cavity on backside enabling very small sensor design on SOI
  -> size reduction of about 60% compared to non DRIE etched sensors

- Ultra Low pressure sensors (SM95) for medical and industrial applications
  -> Pressure range from 0.15 to 1.5 psi
  -> Backside cavity and pressure range adjustment with DRIE process

- Covered under Patents US 7,111,518 and US 8,381,596 B2
Compensation of DRIE non-uniformities

- CD / Overlay run-out towards the wafer edge
  - DRIE CD gets bigger close to wafer edge due to loading effect
  - Cavity shifts in the radial direction at wafer edge due to “outside effect”
- Edge compensation in mask layout to improve CD/Overlay uniformity

Typical CD distribution in X-direction

Typical cavity overlay distribution in X-direction
DRIE formed cavities for pressure sensors

Buried Cavity Technology --- DRIE reference cavity formed and buried in wafer before sensor /CMOS Foundry process

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Classic DRIE Approach</th>
<th>Buried Cavity Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process sequence</td>
<td>Sensor foundry -&gt; DRIE</td>
<td>DRIE -&gt; Sensor foundry</td>
</tr>
<tr>
<td>Etch time</td>
<td>Long, through wafer etch low throughput</td>
<td>Short, shallow cavity etch high throughput</td>
</tr>
<tr>
<td>Cavity CD</td>
<td>Variation across wafer</td>
<td>Precise CD control</td>
</tr>
<tr>
<td>Cavity Overlay</td>
<td>Variation across wafer</td>
<td>Minimized Overlay error</td>
</tr>
<tr>
<td>Edge excl. Zone</td>
<td>Exclusion zone due to DRIE variance</td>
<td>Nearly no exclusion zone required</td>
</tr>
<tr>
<td>CMOS compatibility</td>
<td>Plasma Damage could impact CMOS circuits</td>
<td>Compatible</td>
</tr>
</tbody>
</table>
Content

1) SMICompany Overview

2) DRIE Etch for MEMS pressure sensor miniaturization

3) Automated Optical Inspection (AOI) for defect detection in MEMS Devices
Automated Optical Inspection (AOI)

- Automated Optical Inspection (AOI) scans the wafer surface and automatically detects defects and classifies them.
- ICOS, originating in Belgium and acquired in 2008 by KLA Tencor, built the equipment.
- The system is equipped with one central loader and two inspection modules with high speed line cameras.
Importance of visual inspection for MEMS devices

- Defects that cannot be caught by electrical tests and cause reliability / performance impacts

**Bond Void on the backside**
- Could cause a leak for absolute pressure sensors

**Cracks in Membrane**
- Falsifies the pressure signal
- Reliability problem
Importance of visual inspection for MEMS devices

- Defects that cannot be caught by electrical tests and cause reliability / performance impacts

**Mis-shaped cavity**
- influence on pressure non-linearity
- modified sensitivity

**Defects in backside metallization**
- could weaken eutectic bond
- reliability problem
Criteria and methods to detect different defects
Frontside Inspection

**Metal Area**
- Inspects for scratches and contamination in the metal region
- Example for the criteria used to detect the defect

<table>
<thead>
<tr>
<th>Enable</th>
<th>Bin</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️</td>
<td>Metal</td>
<td>Polarity IS Dark (\text{AND}( \text{...}))</td>
</tr>
</tbody>
</table>

**Membrane Area**
- Inspects for fractures and contamination on the membrane
- Example

<table>
<thead>
<tr>
<th>Enable</th>
<th>Bin</th>
<th>Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>✔️</td>
<td>Broken Cavity</td>
<td>(\text{Length} \geq \text{AND Elongation} \geq 35)</td>
</tr>
</tbody>
</table>
Criteria and methods to detect different defects
Backside Inspection

Bond Void Area
- Inspects for voids in the bond interface outside the cavity area
- Example

Diaphragm Area
- Inspects for cracks and contamination inside the diaphragm region
- Example
Inspection at different stages

Focus on specific defects in the different stages of the process

- Bond interface and membrane defects after bonding
- Defects in backside metal that influence eutectic bond
- Inspection after sawing for saw chipping and cracks
Inspection record to document quality

- Defect was not on the Die at AOI
- Reassure customer of excellent quality

-> Defect must have occurred at customer site, finish with 5D report
Defect Reduction Program

- Screening with AOI after different steps in the process
- Correlation of defect to certain equipment used at that point
Classification and Yield Analysis using Pareto

### Automated defect classification
- type of defect
- area where it is detected

### Shortcut keys for fast Operator reclassification during review

### Visual of a wafer map for quick overview for Operators / Engineers

<table>
<thead>
<tr>
<th>Color</th>
<th>Name</th>
<th>Output code</th>
<th>Shortcut key</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To be inspected</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reject before</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pass</td>
<td></td>
<td>F1</td>
</tr>
<tr>
<td></td>
<td>Invalid</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reference die</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reference die - Invalid</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reference die - Not Found</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>uneven cavity</td>
<td>62</td>
<td>Num 2</td>
</tr>
<tr>
<td></td>
<td>saw chip/cracked die</td>
<td>63</td>
<td>Num 3</td>
</tr>
<tr>
<td></td>
<td>back side scratch</td>
<td>64</td>
<td>Num 4</td>
</tr>
<tr>
<td></td>
<td>back side contamination</td>
<td>65</td>
<td>Num 5</td>
</tr>
<tr>
<td></td>
<td>broken diaphragm</td>
<td>68</td>
<td>Num 8</td>
</tr>
<tr>
<td></td>
<td>probe reject</td>
<td>66</td>
<td>Num 6</td>
</tr>
<tr>
<td></td>
<td>front side scratch</td>
<td>67</td>
<td>Num 7</td>
</tr>
<tr>
<td></td>
<td>front side contamination</td>
<td>69</td>
<td>Num 9</td>
</tr>
<tr>
<td></td>
<td>discolored field front side</td>
<td>70</td>
<td>/</td>
</tr>
<tr>
<td></td>
<td>etch pit</td>
<td>71</td>
<td>Num *</td>
</tr>
<tr>
<td></td>
<td>front side KOH, stained pad</td>
<td>72</td>
<td>Num -</td>
</tr>
<tr>
<td></td>
<td>deep probe/ no probe marks</td>
<td>73</td>
<td>Num +</td>
</tr>
<tr>
<td></td>
<td>FS litho defect, missing metal</td>
<td>74</td>
<td>Insert</td>
</tr>
<tr>
<td></td>
<td>other/PCM/missing die</td>
<td>75</td>
<td>Home</td>
</tr>
<tr>
<td></td>
<td>delamination/bond void</td>
<td>60</td>
<td>Num 0</td>
</tr>
</tbody>
</table>

**Reject Classification List**

**Wafer ID:**
- #Inspected: 25,665
- #Pass: 25,051
- #Reject: 614
- #Invalid: 0

**Slot ID:**
- Yield: 97.61%

-> Basis for Pareto Analysis
Pareto Analysis of Defect types improves the efficiency to increase Yield

Wafer level Yield has been improved at SMI by 5% as an average over all products in the last 3 years by using Automated Optical Inspection (some products up to 10%)
## Automated Classification to reduce time & cost

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Automated Optical Inspection</th>
<th>100% Operator Inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front and Back Inspection on SM68 Sensor</td>
<td>~ 25 minutes machine time ~ 0 to 15min. Operator review time per wafer</td>
<td>~ 8 hours per wafer</td>
</tr>
<tr>
<td>Front and Back Inspection on SM95 Sensor</td>
<td>~ 10 minutes machine time ~ 5 to 15min. Operator review time per wafer</td>
<td>~ 2 hours per wafer</td>
</tr>
</tbody>
</table>

- The required throughput of > 40M sensors shipped per year would not have been possible without AOI and not sacrificing quality assurance
- The cost per wafer and the required Operators were reduced significantly
- Customers rely on SMI`s quality inspection using AOI as an essential part of the 0ppm automotive strategy
Acknowledgements

Special Thanks for preparing this presentation go to

Dr. Shaoxin Lu for the DRIE Etch portion
Abhishek Davray for the AOI portion
Dr. Steve Terry and Marc Konradt for Technology & Process
Raul Figueroa for the SMI Company Overview
Thank you !
DISCLAIMER

This presentation contains forward-looking statements based on beliefs of Silicon Microstructures’ management. Such statements reflect the company’s current views with respect to future events and are subject to risks and uncertainties. Many factors could cause the actual results to be materially different, including, among others, changes in general economic and business conditions, changes in currency exchange rates and interest rates, introduction of competing products, lack of acceptance of new products or services and changes in business strategy. Actual results may vary materially from those projected here. Silicon Microstructures does not intend or assume any obligation to update these forward-looking statements.