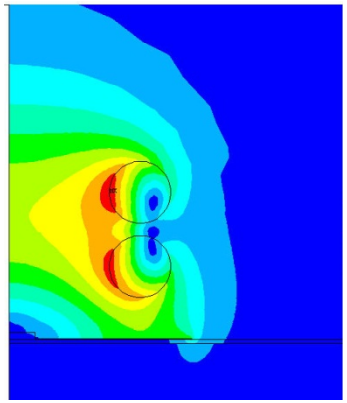
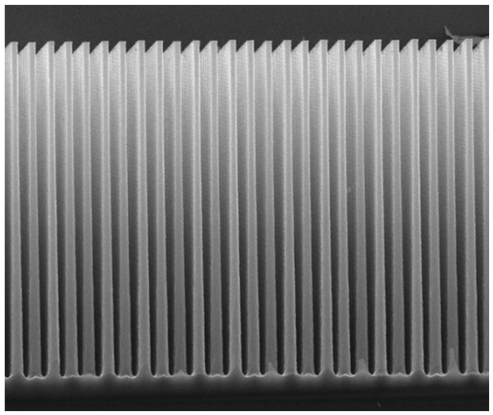
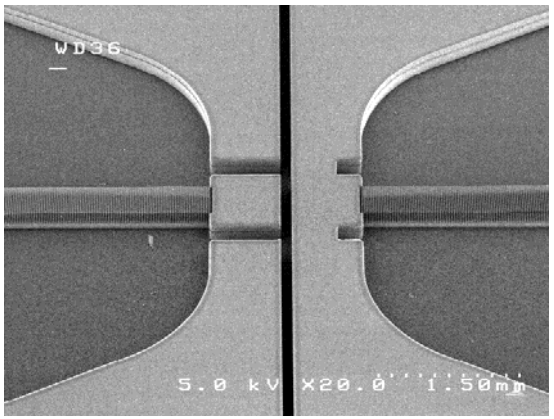
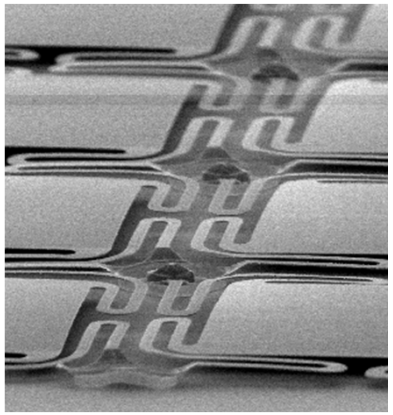
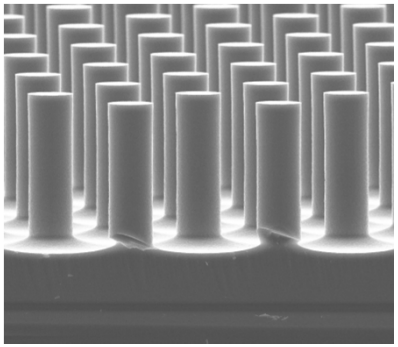
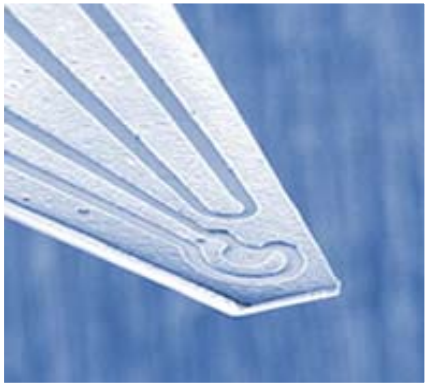
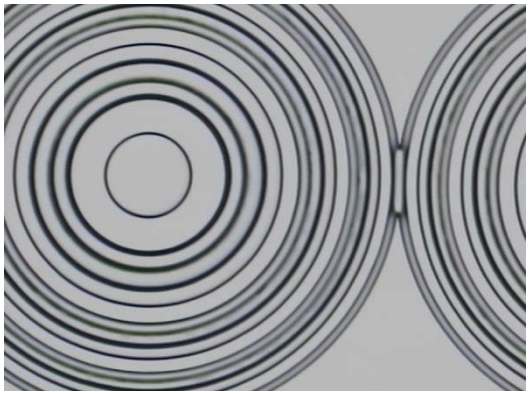
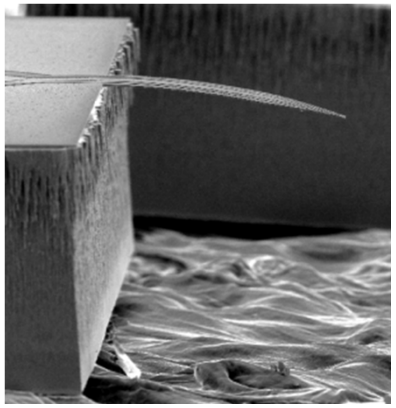
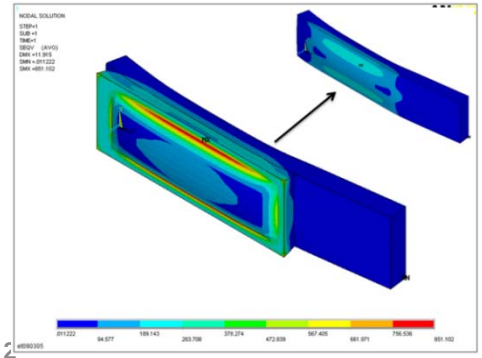
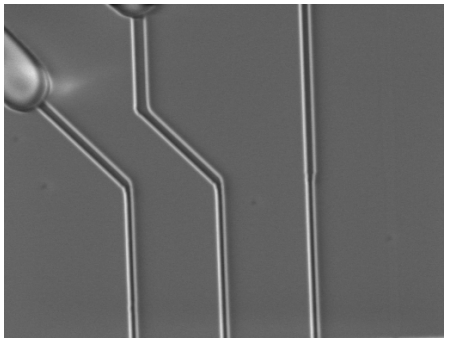
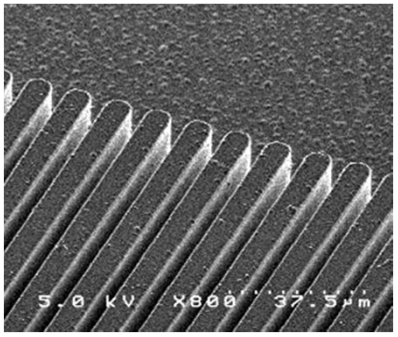
AMFitzgerald Company Overview

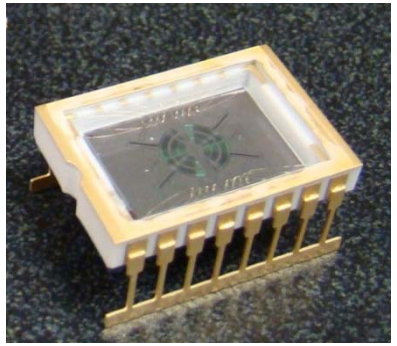
July 2014

AMFITZGERALD
& ASSOCIATES

Mission: Your Partner in MEMS Product Development



Company background

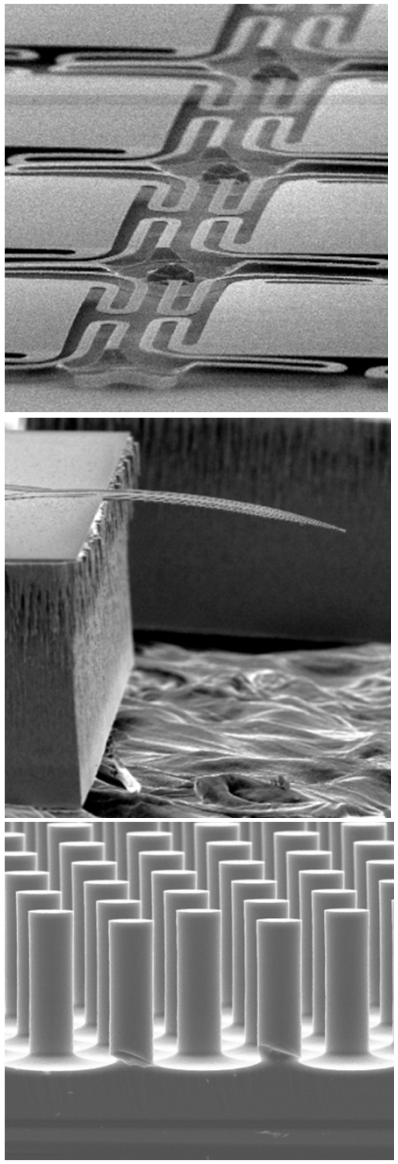
- **Founded 2003 by Alissa M. Fitzgerald, self-funded**
- **Burlingame, CA: near SFO and Silicon Valley**
- **Goal: to be the premier MEMS product development firm**
- **Consistent growth**
  - **Over 125 clients served to date**
- **Active member of the MEMS Industry Group**

Headquarters in Burlingame, CA

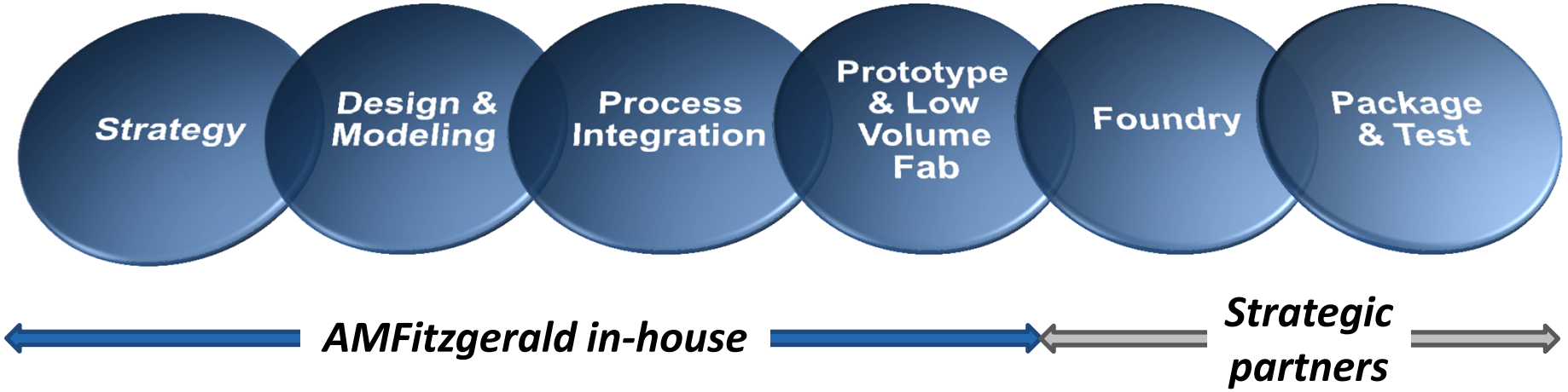
Fab operations at 1500m^2
UCBerkeley Marvell Nanolab

Our value

- **First time developing MEMS?**
  - **We can provide a complete solution**
- **Improving your MEMS product?**
  - **Let us optimize your design**
- **Investing in MEMS?**
  - **Valuable insight from expert practitioners**
- **Our competitive advantage**
  - **A complete MEMS solution**
  - **Expert design and process engineers**



A complete supply chain from concept to production



- **Multi-disciplinary, expert engineering team**
- **Custom MEMS development from start to finish**
- **Design and process integration for volume production**
- **In-house prototype fabrication, easy transition to production partners**

Production solutions

A menu to satisfy different customer needs

Full custom low volume

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Open search for foundry partner

Full custom high volume

Open search for foundry partner

Fast time to market with foundry-specific design

micralyne

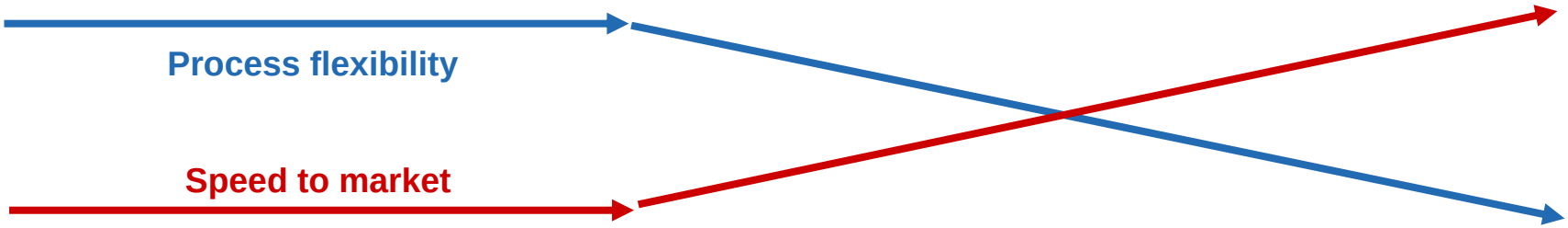
silex MICROSYSTEMS

FAB MIXED-SIGNAL FOUNDRY EXPERTS

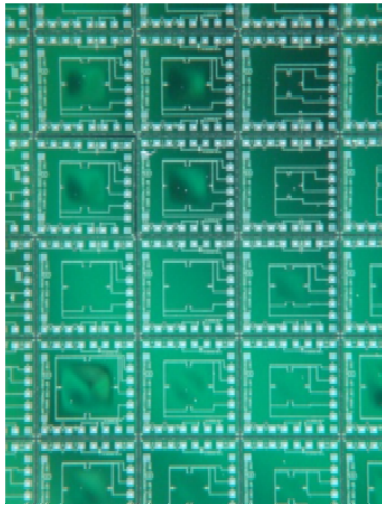
Faster time to market with semi-custom sensors

Fastest time to market with standardized 200mm process

InvenSense
Innovation in MEMS



AMFitzgerald's RocketMEMS^{TM}: Semi-custom sensors

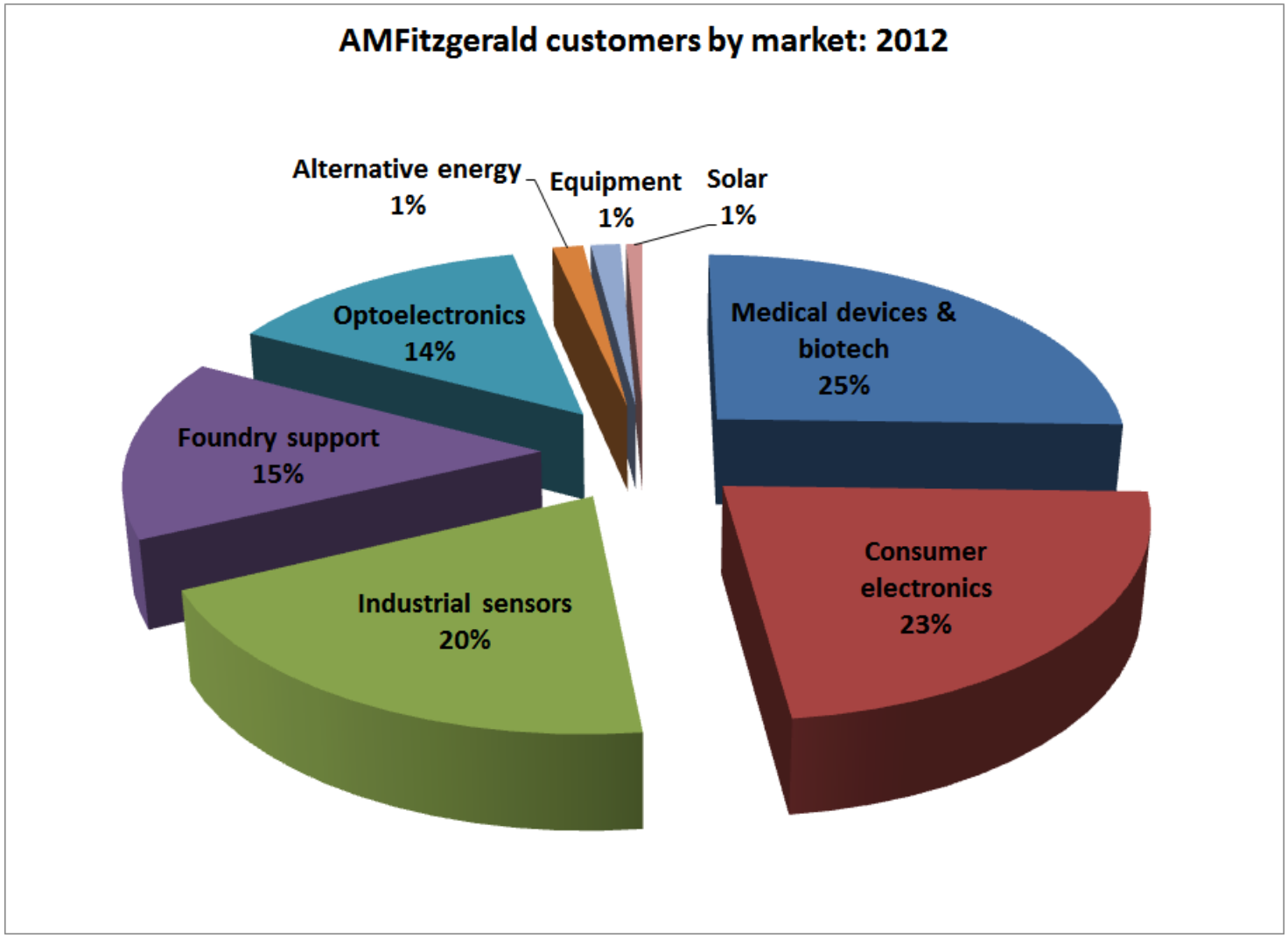


Variety of RocketMEMS Pressure Sensors

- **MEMS solutions for OEMs and system integrators**
  - **AMFitzgerald reference designs**
  - **ISO-certified foundries**
  - **Cost-effective multi project wafer runs**

1. **Customer provides desired sensor specification**
2. **AMFitzgerald tailors reference design to meet customer's spec**
3. **Silex manufactures wafers**
4. **AMFitzgerald tests and delivers sensors to customer**

Our diverse customer base



Types of MEMS developed in 2012:

- Optical switch
- Microfluidics
- Microphone
- Timing
- Microtexture
- Inkjet
- Radiation
- Motion
- Pressure
- Micro-mirror
- Cantilever
- IR imager
- Fuel cell
- Display
- Chemical

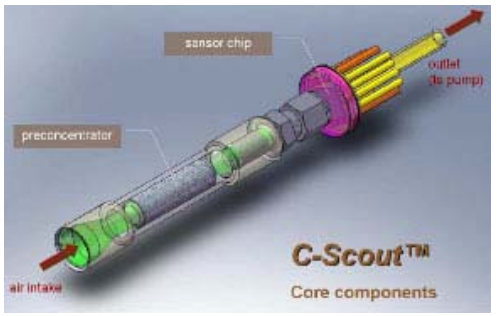
MEMS type core competencies

- **Sensor types**
  - **Motion, pressure, acoustic, infrared, magnetic, radiation, resonators, chemical**
- **Transduction principles**
  - **Piezoresistive, piezoelectric, electrostatic, capacitive**
- **Actuators**
  - **Electrostatic, piezoelectric**
- **Microfluidics**
- **Micromolds and surface texturing**

AMFitzgerald Client Products

Cantimer OSMO Dehydration Sensor

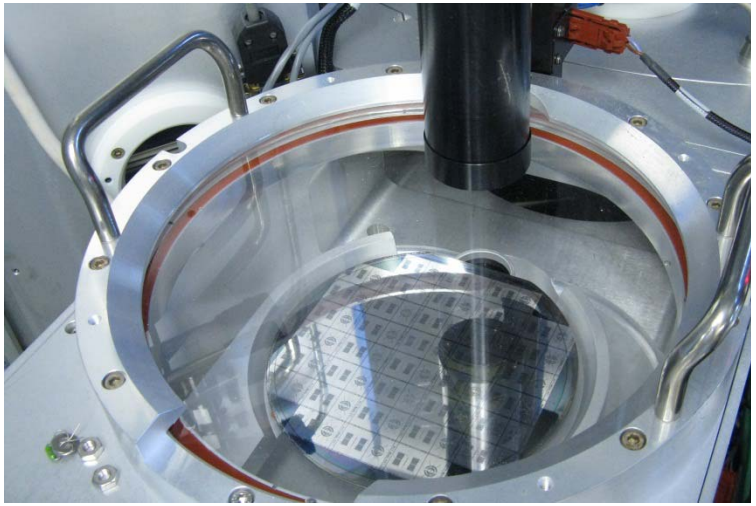
Fluxion Biosciences BioFlux product



NNTS C-Scout product

MEMS process core competencies

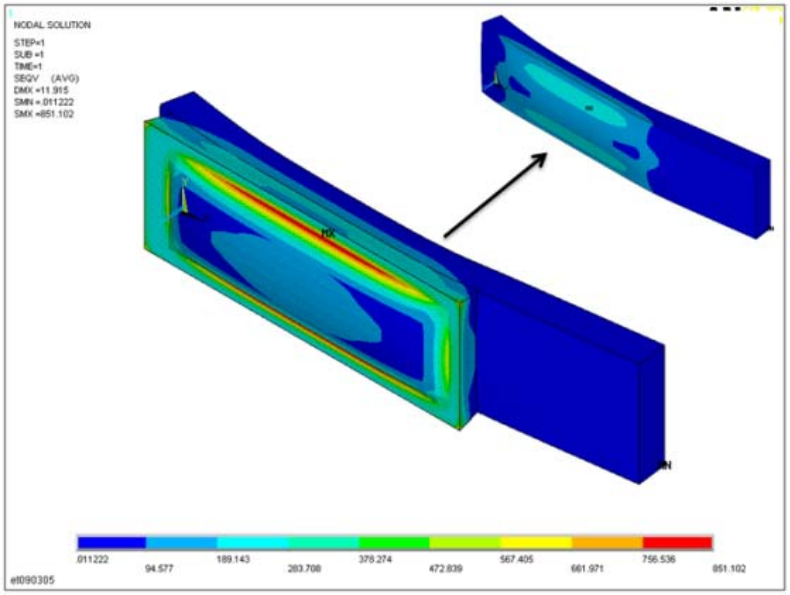
- **All MEMS process techniques**
- **Process specialties:**
  - **Thick lithography**
  - **High aspect ratio silicon etch**
  - **Sacrificial release by vapor HF or XeF2**
  - **Aluminum nitride and other new materials**
  - **Silex Sil-Via TSV**
  - **Laser and abrasive drilling**
  - **Stealth dicing**
- **Managing risk and uncertainty of MEMS R&D**



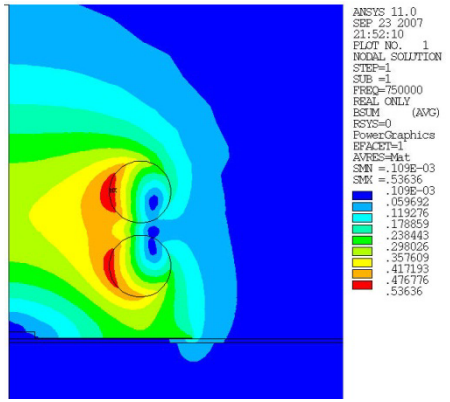
MEMS design core competencies

- **ANSYS Multiphysics**
- **Tanner EDA L-Edit**
- **SoftMEMS**
- **Matlab**
- **Proprietary fracture prediction**

- **Intelligent use of simulation to minimize risk and reduce fab cycles**
  - **Management of uncertainty in MEMS material properties**



Package-induced stresses



Magnetic field of inductor coils

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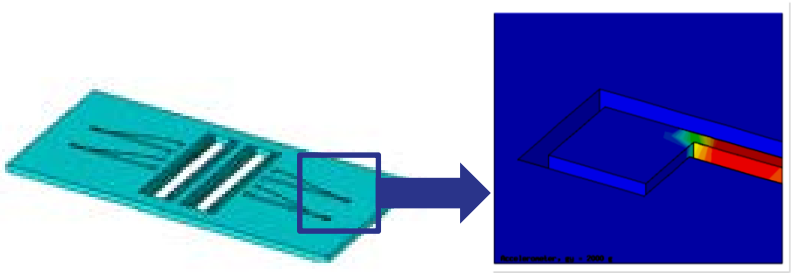
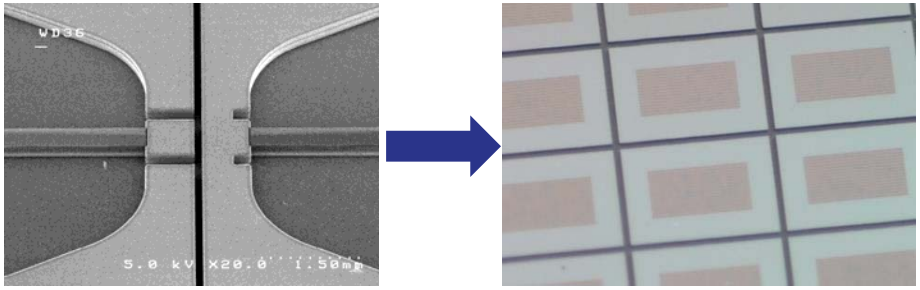
Case studies: Design and process integration

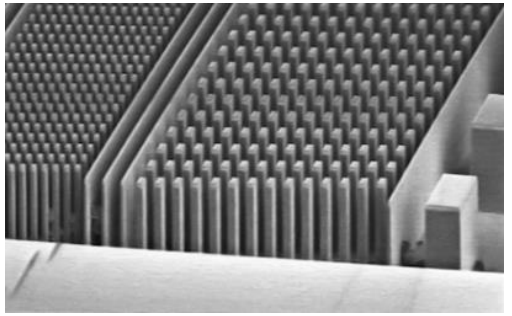
- **Accelerometer:**
  - Design to specification
  - Fabrication on the InvenSense NF Shuttle



- **Microfluidic pump:**
  - Redesign to lower cost of fabrication
  - Prototype, then foundry transfer

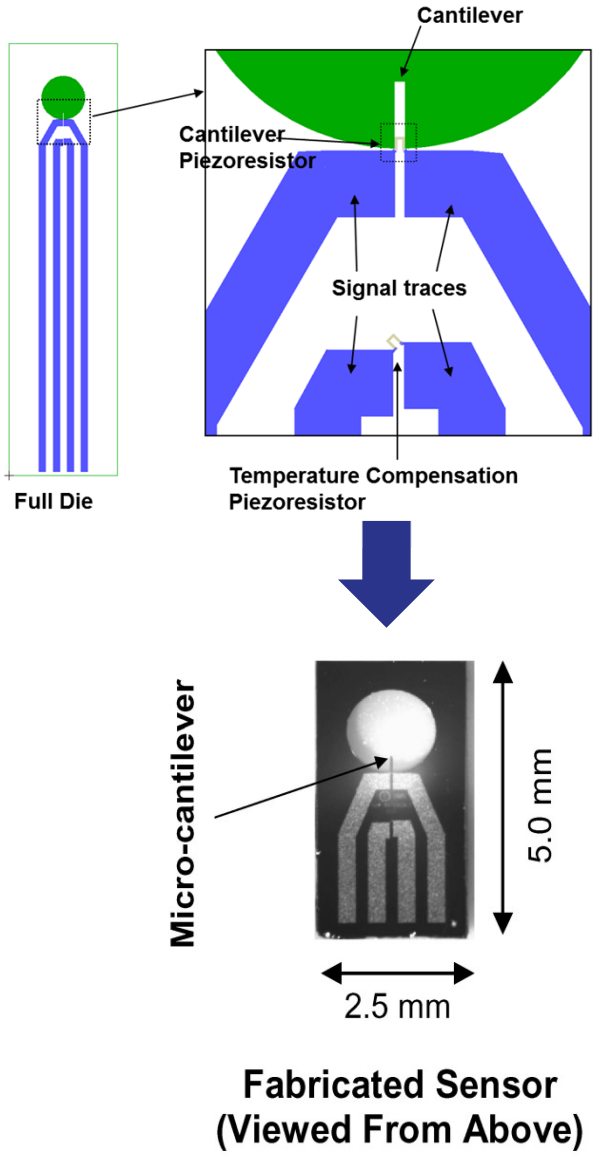


- **Process improvement:**
  - Improved DRIE aspect ratio from 20:1 to 46:1 on existing toolset



Case study: From concept to manufacturing

- **Cantimer dehydration sensor**
- **Development**
  - **First prototypes functional (7 layer process)**
  - **Piezoresistor value matched simulation**
- **Foundry Transfer**
  - **Bidding and diligence process with five foundries**
  - **Die shrink**
  - **Transfer of AMFitzgerald prototype enabled > 90% yield on the first run**



Business process: custom R&D

- **Initial meeting: fit and scope of work**
- **Detailed project plan and cost proposal provided**
- **Project performed in discrete Phases to minimize risk**
  - **Phase 1: Design exploration**
  - **Phase 2: Prototype fabrication 1**
  - **Phase 3: Test and design iteration**
  - **Phase 4: Prototype fabrication 2**
  - **Etc.**
- **Collaborative interactions**
- ***Client owns all work product and intellectual property***
  - **Including masks and runsheets, which will be transferred to foundries**

The secrets to MEMS development success

- **Have adequate funds and timeline for multiple prototype iterations**
- **Robust designs do not push process tolerances**
- **Bring only mature prototypes to foundry**

Public client list (partial)

Startups and Small-Medium Businesses:

Advanced Diamond Technologies
Bay Materials LLC
CPAC
Cantimer, Inc.
Edge Embossing LLC
Endotronix
Fluxion Biosciences
Hepregen
Microfabrica
Micralyne
NovaSpectra
PolyOptic Technologies
SemQuest
Silicon Light Machines
Silicon Microstructures
Tactus Technologies
Wave 80 Biosciences
Yole Développment

Public Companies:

Agilent Technologies
Applied Materials
Caliper LifeSciences
Cypress Semiconductor
Maxim Integrated
Measurement Specialties
Micrel
Mirion
Panasonic ACOM-TC
Sorin
Symmetricom
Ricoh Innovations

Research Institutions:

Alfred E. Mann Foundation
DARPA
MIT
Stanford University
Stowers Institute
UCSF, Opthalmology
Weill Medical College of Cornell Univ.

Company contact information

700 Airport Blvd. Suite 210
Burlingame, CA 94010, USA
Phone: +1 (650) 347 MEMS
Fax: +1 (650) 347 6366
General Inquiries: info@amfitzgerald.com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