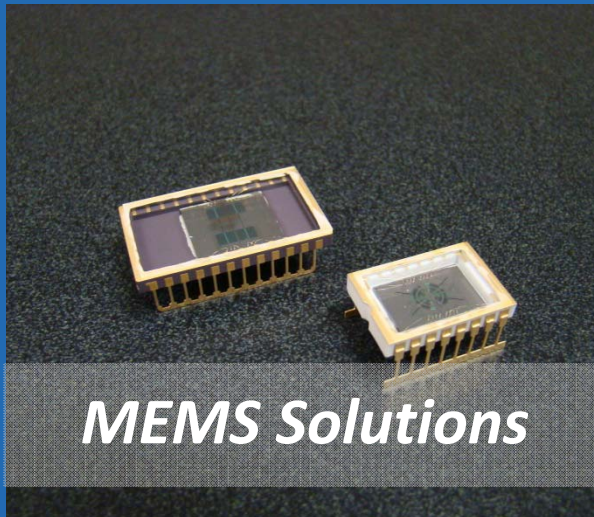
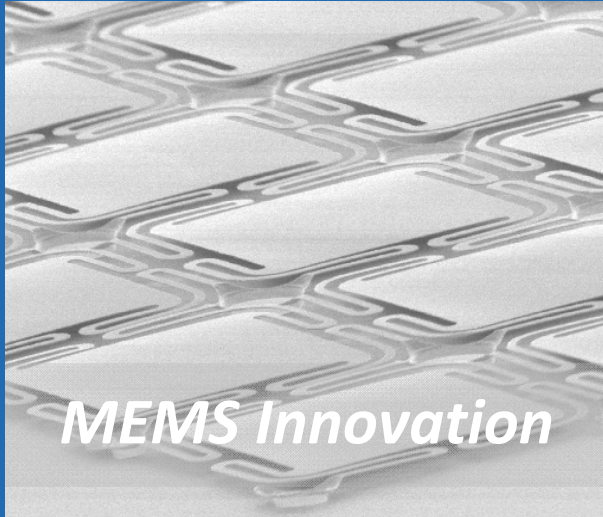


AMFitzgerald Company Overview

January 2015



AMFitzgerald services



**Creation of novel
designs and IP**

**Paths to
manufacturing and
market**

**Key insights from
MEMS experts**

Company background

- **Mission:** to be the premier MEMS product development firm
- **Founded 2003** by Alissa M. Fitzgerald, privately held
- **Locations:**
 - Office: Burlingame, CA, near SFO and Silicon Valley
 - Fab: 1500m² fab at UC Berkeley, CA
- **Consistent growth**, over 125 clients served to date
- **Active in the MEMS Industry Group**



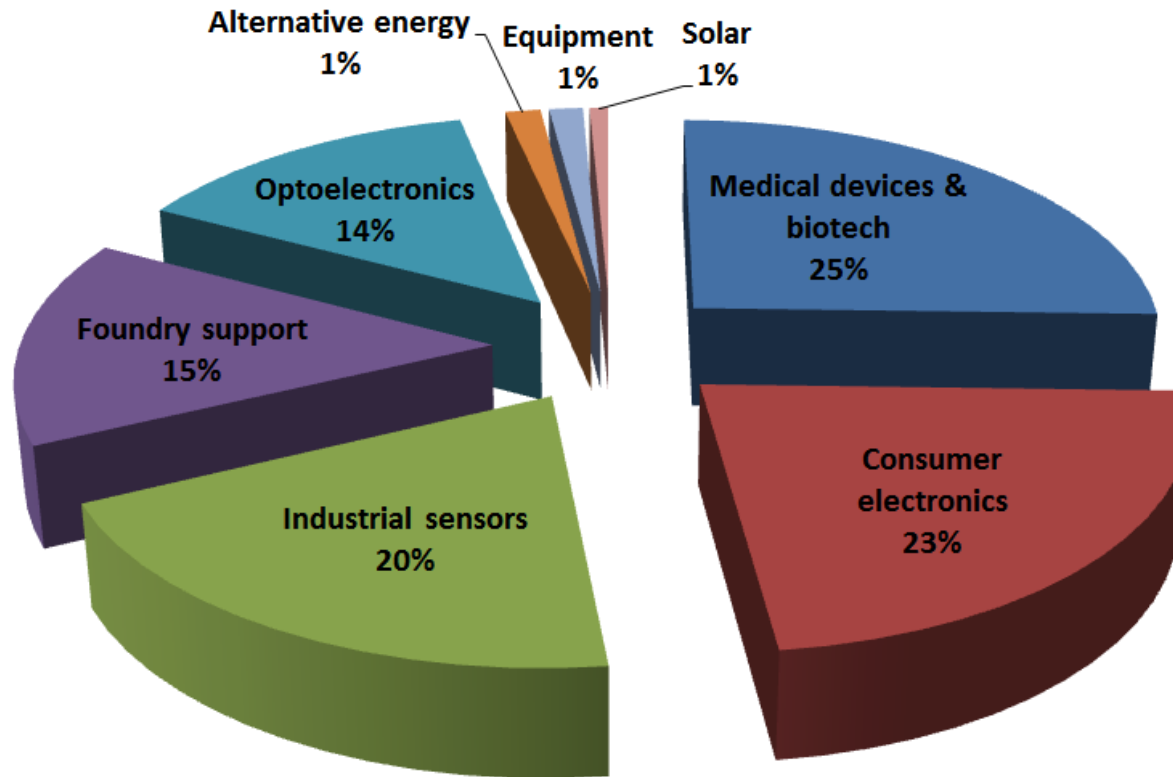
Headquarters in Burlingame, CA



Our fab operations at 1500m²
UC Berkeley Marvell Nanolab

Our diverse customer base

AMFitzgerald customers by market: 2012



Types of MEMS developed in 2012:

Optical switch

Microfluidics

Microphone

Timing

Microtexture

Inkjet

Radiation

Motion

Pressure

Micro-mirror

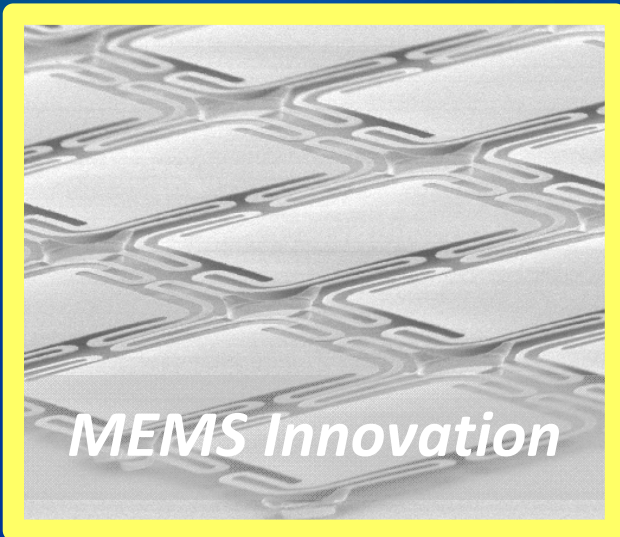
Cantilever

IR imager

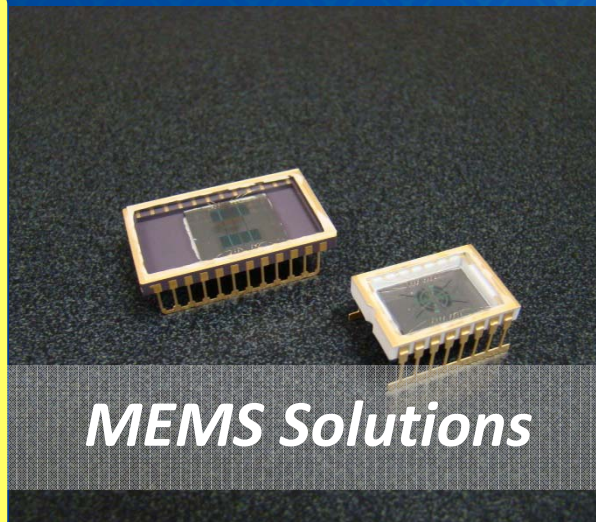
Fuel cell

Display

Chemical



MEMS Innovation



MEMS Solutions



Technology Strategy

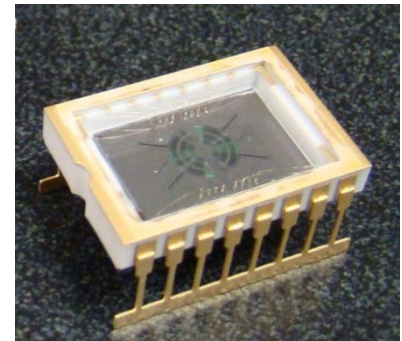
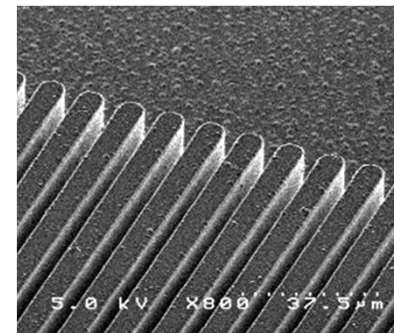
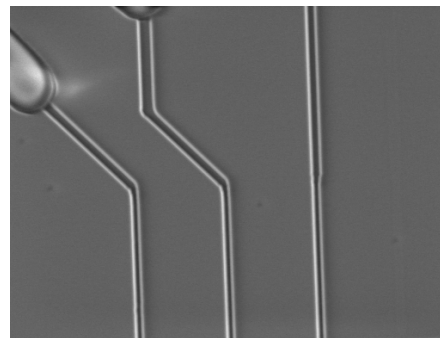
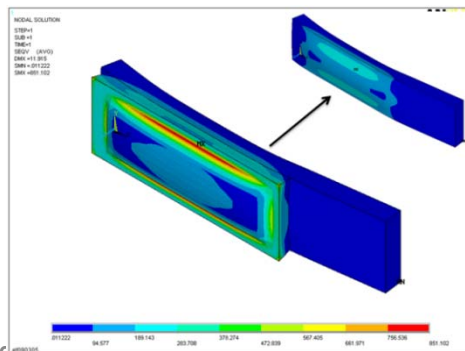
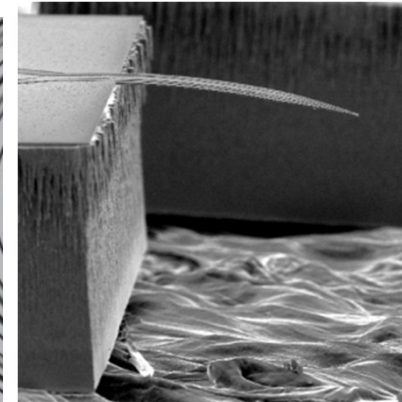
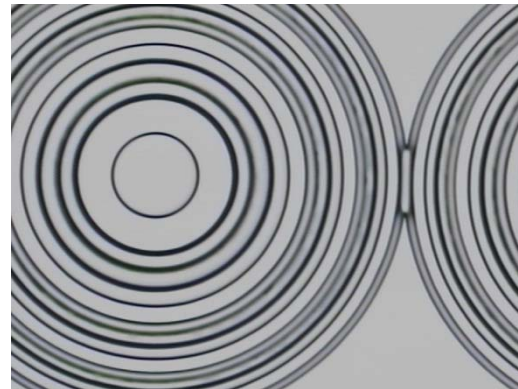
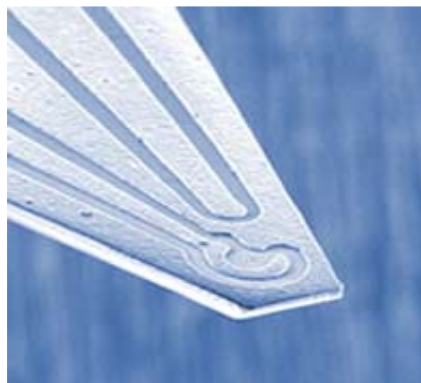
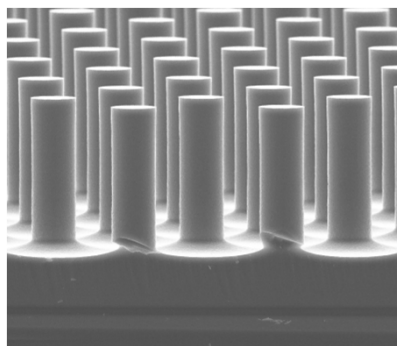
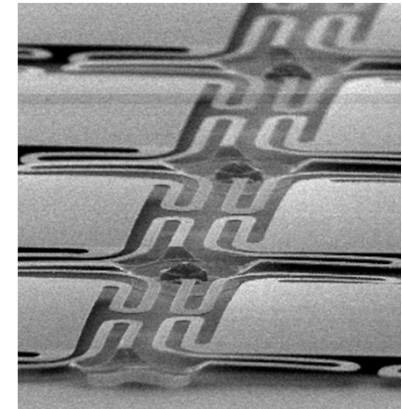
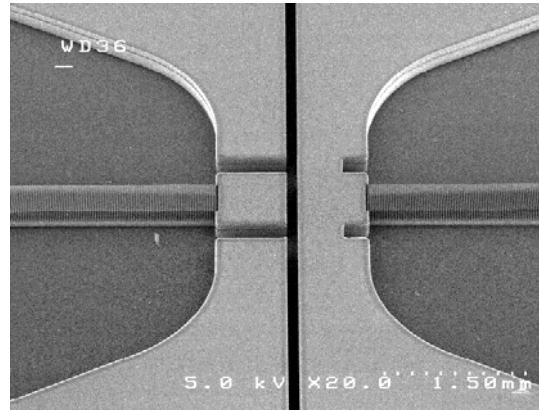
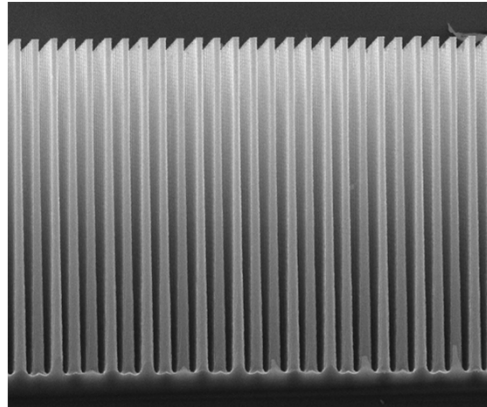
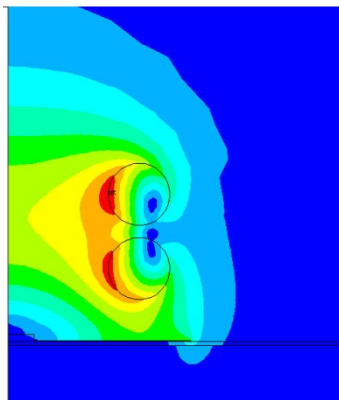
LWIR Bolometer Pixel Array, MEMS fabricated over CMOS

Designed and fabricated by AMFitzgerald

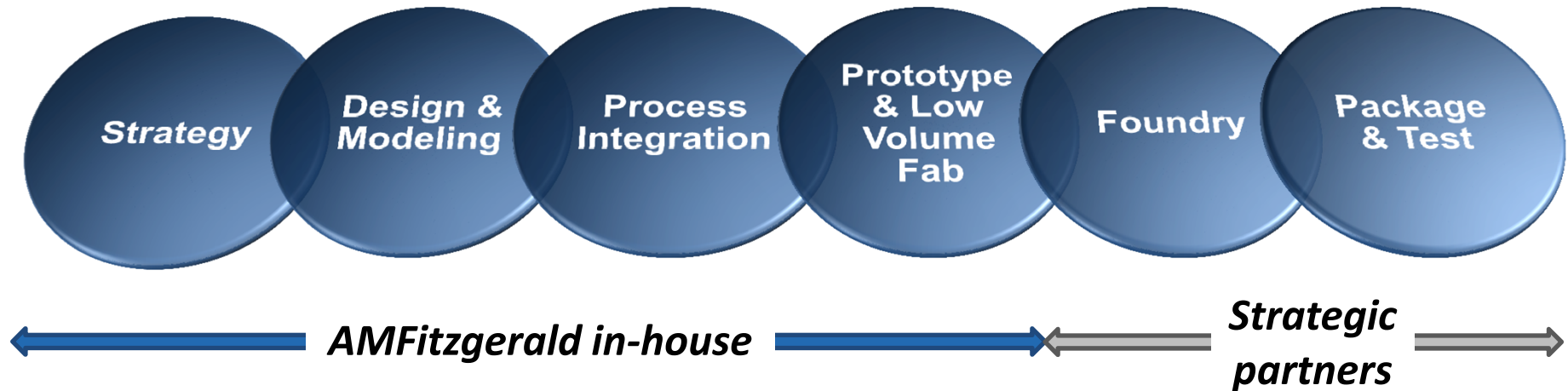
MEMS Innovation Services

Novel designs and IP creation

Innovation: examples of our work



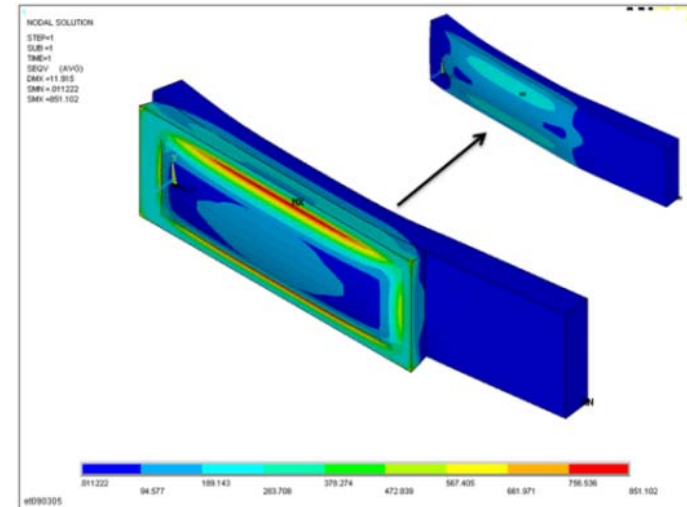
Full development services from concept to production



- **Advantages of working with us:**
 - Multi-disciplinary, expert engineering team focused on MEMS development for volume production
 - Rapid prototyping on state-of-the-art tools common to foundries
 - Own all the design and process IP
 - Bring a mature, de-risked design to the foundry to get better pricing and faster time to production

MEMS core competencies

- **Transducer physics**
 - Piezoresistors, piezoelectrics, capacitive, magnetic, thermal, resonant
- **Sensor types**
 - Motion, pressure, acoustic, infrared, magnetic, radiation, resonators, chemical, gas, particles
- **Actuator types**
 - Motors, switches, valves, pumps
- **MEMS fabrication expertise:**
 - Mask layout
 - Full multiphysics simulation
 - Process integration and all fabrication processes
 - Design for manufacture



ANSYS Multiphysics simulation saves money and time in the fab



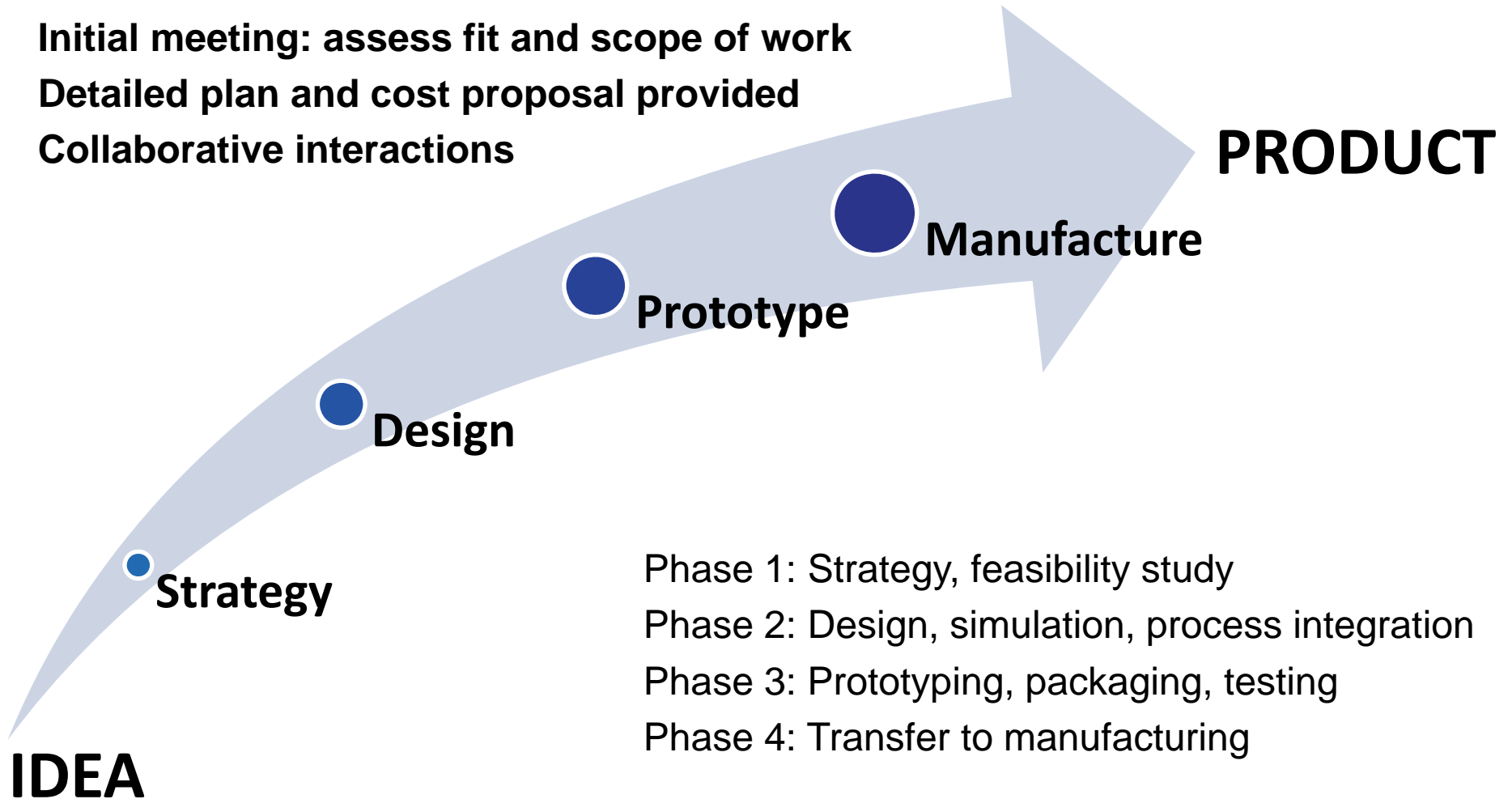
In-house prototyping by our expert engineers

Our innovation process: phased development

Initial meeting: assess fit and scope of work

Detailed plan and cost proposal provided

Collaborative interactions



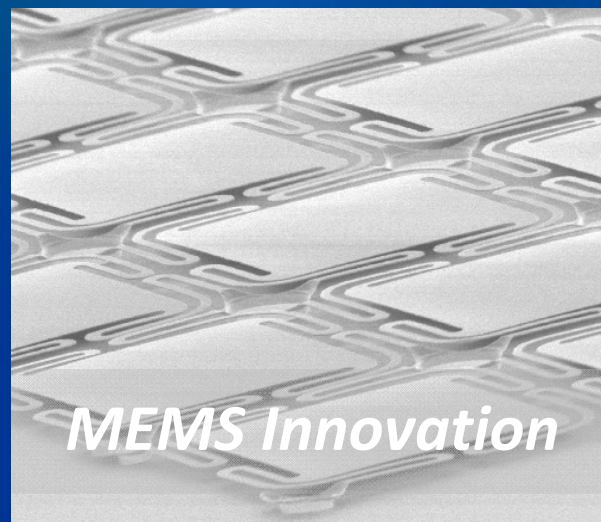
Phase 1: Strategy, feasibility study

Phase 2: Design, simulation, process integration

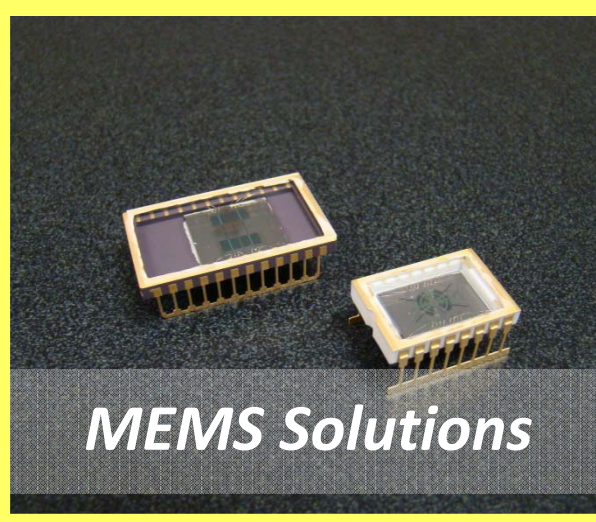
Phase 3: Prototyping, packaging, testing

Phase 4: Transfer to manufacturing

Client owns all work product



MEMS Innovation



MEMS Solutions



Technology Strategy

Linear and Rotary Micro-optical Fiber Switches

Designed by AMFitzgerald, fabricated by foundry partner, packaged by assembly partner

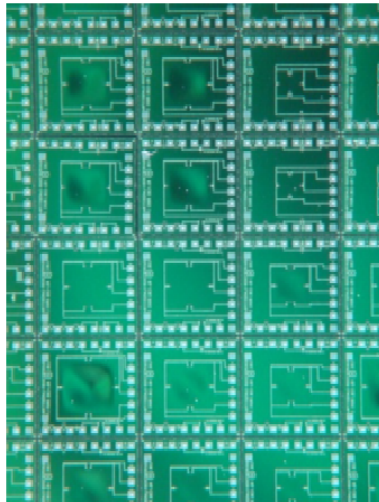
MEMS Solutions Services

Paths to manufacturing and market

AMFitzgerald's RocketMEMS®: Semi-custom sensors



- **MEMS solutions for OEMs and system integrators**
 - Leverage existing designs and processes for faster time to market
 - AMFitzgerald's design library
 - ISO-certified foundries
 - Pressure sensors now available
 - More sensor types in future



Variety of RocketMEMS
Pressure Sensors

RocketMEMS engagement:

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

Foundry production solutions

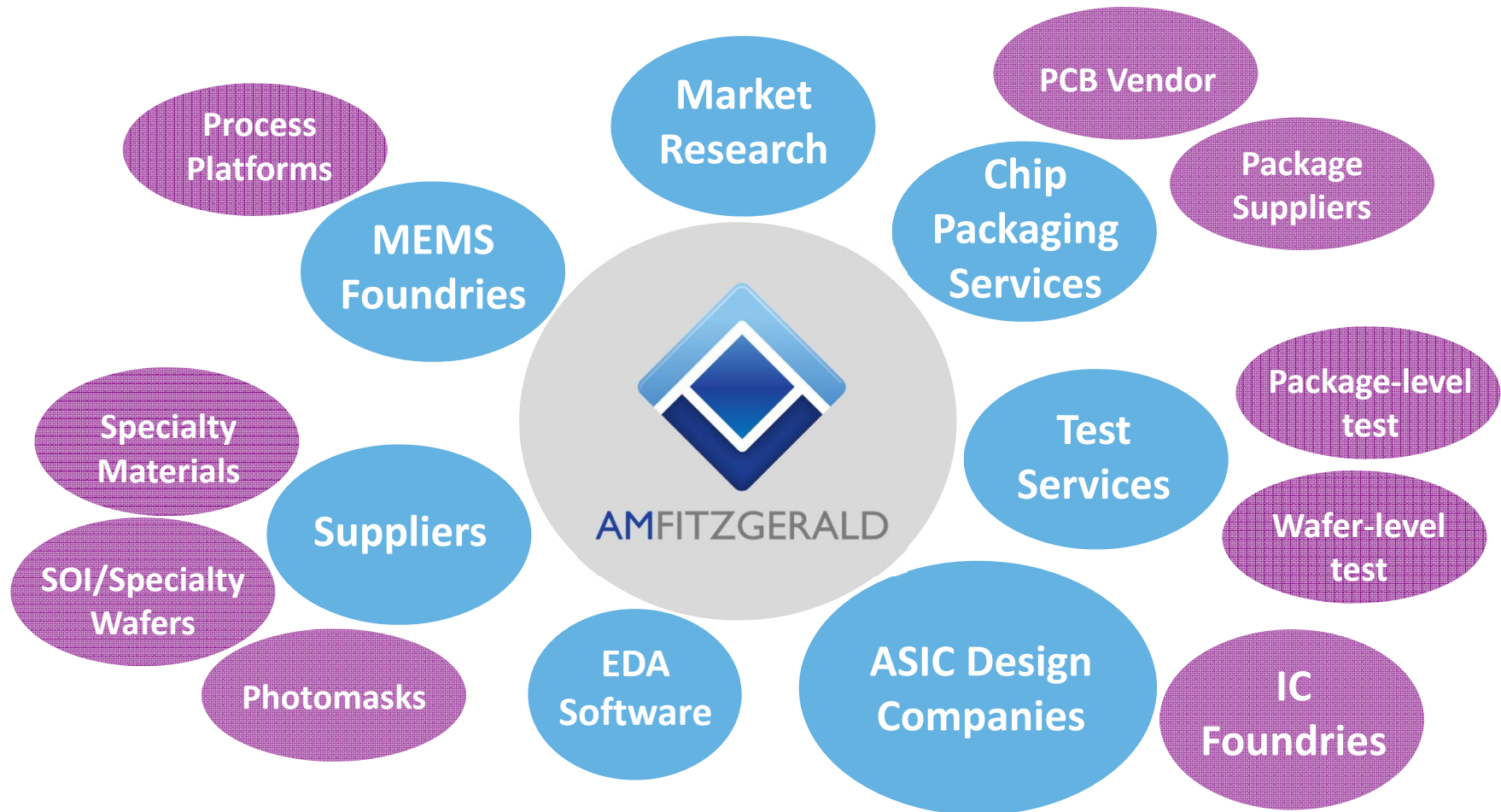
We will help you select and transfer to the optimal manufacturing partner(s) for your technology and business needs

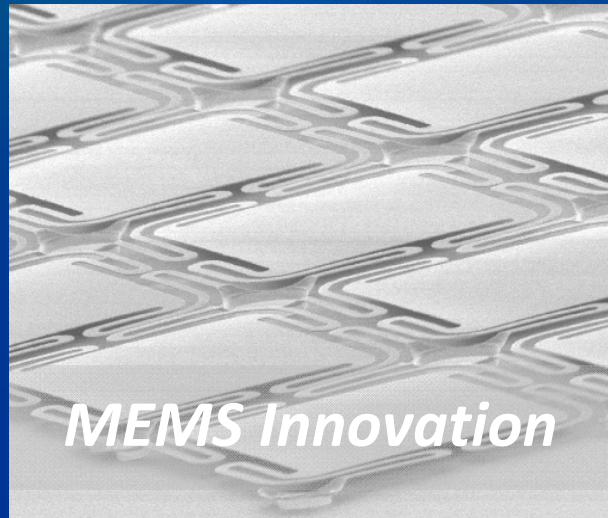


Process flexibility

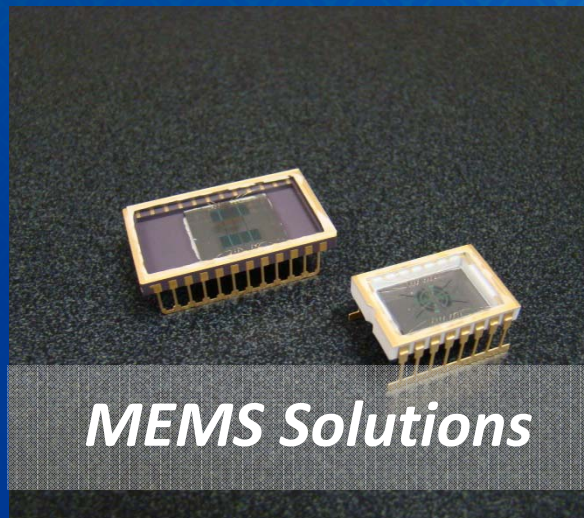
Speed to market

An ecosystem of trusted partners for a variety of solutions





MEMS Innovation



MEMS Solutions



Technology Strategy

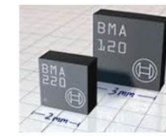
Technology Strategy Services

Key insights from MEMS experts

Technology Strategy

- **Competitive Intelligence**
 - How to win in the MEMS market
 - Players, analysis of market data and research reports
 - Emerging technologies
 - Cost and risk analysis
- **Make vs. Buy Analysis**
 - Develop MEMS specification
 - Survey COTS options
 - ‘Make’ scenarios
 - Cost and risk analysis
- **Patent Landscaping**
 - Technical analysis of patent families
 - Design-around analysis
 - Prior art and public domain searches

Types of commercially-available MEMS sensors



Accelerometers



Microphones



Pressure sensors



Gyroscopes



Oscillators



Magnetometers



Thermopiles



RF components

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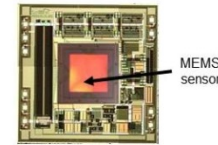
Technology Strategy, cont'd

- **Workshops**
 - Half-day or full-day presentations to get your team quickly up to speed on what you need to know about MEMS
 - Content tailored to your specific business interests
 - Ask-the-expert Q&A
 - In-person or via WebEx
- **Typical customer profile**
 - M&A groups, investors
 - Business development groups
 - Corporate executives

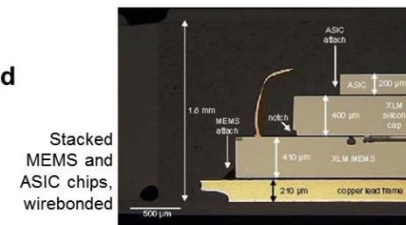
Why MEMS are exciting for so many applications

- **Smaller, better, cheaper**
 - But not always all three
- **Ease of electronics integration enables sophisticated capabilities in small form factor:**
 - Multiple sensors
 - Signal processing and analysis
 - Telemetry capability
 - Low power

Integrated Pressure Sensor



Source: IMD

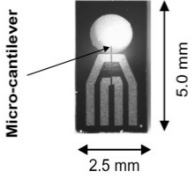


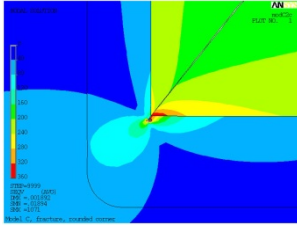


Source: Chipworks/Kionix

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How we have helped our customers

Case studies																																
Innovation	Solutions		Strategy																													
<div><p>Micro-cantilever</p><p>5.0 mm</p><p>2.5 mm</p><p>Fabricated Sensor (Viewed From Above)</p></div> <p>Complete development of a novel dehydration sensor from concept to manufacturing</p>	<div><p>1D accelerometer designed to customer specification, fabricated on InvenSense's NF Shuttle</p></div>	<div><p>Re-design of a microfluidic pump in order to shrink chip size and to lower cost</p></div>	<div><p>Improved reliability of a photonic device through failure analysis and re-design</p></div>	<p>MEMS manufacturing is > 20 years behind CMOS</p> <table><thead><tr><th>MEMS</th><th>CMOS-like MEMS</th><th>Mixed signal analog</th><th>CMOS Si</th></tr></thead><tbody><tr><td>Bespoke</td><td></td><td></td><td>Standardized</td></tr><tr><td>No standard processes, methods</td><td>Fully standardized process</td><td></td><td></td></tr><tr><td>Design simulation weak</td><td>Advanced, proven simulation</td><td></td><td></td></tr><tr><td>Supply chain immature</td><td>Supply chain mature</td><td></td><td></td></tr><tr><td>No physical scaling</td><td>Moore's law (until recently)</td><td></td><td></td></tr><tr><td>4+ years to commercialize new designs</td><td>< 2 years to commercialize new designs</td><td></td><td></td></tr></tbody></table> <p>Workshop for semiconductor company executives on opportunities in the MEMS industry</p>	MEMS	CMOS-like MEMS	Mixed signal analog	CMOS Si	Bespoke			Standardized	No standard processes, methods	Fully standardized process			Design simulation weak	Advanced, proven simulation			Supply chain immature	Supply chain mature			No physical scaling	Moore's law (until recently)			4+ years to commercialize new designs	< 2 years to commercialize new designs		
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More case studies and references available upon request

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 Développement

Public Companies:

Agilent Technologies
Applied Materials
Caliper LifeSciences
Cypress Semiconductor
Finisar
Maxim Integrated
Measurement Specialties
Micrel
Mirion
Panasonic ACOM-TC
Sorin
Symmetricom (now part of Microsemi)
Ricoh Innovations

Research Institutions:

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

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