Letting Process Drive Design

The RocketMEMS® Model

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& ASSOCIATES

Overview

- About us
- The ‘Long Tail’ of the MEMS market
- Customer profile: System integrators
- What’s wrong with MEMS development
- The RocketMEMS model

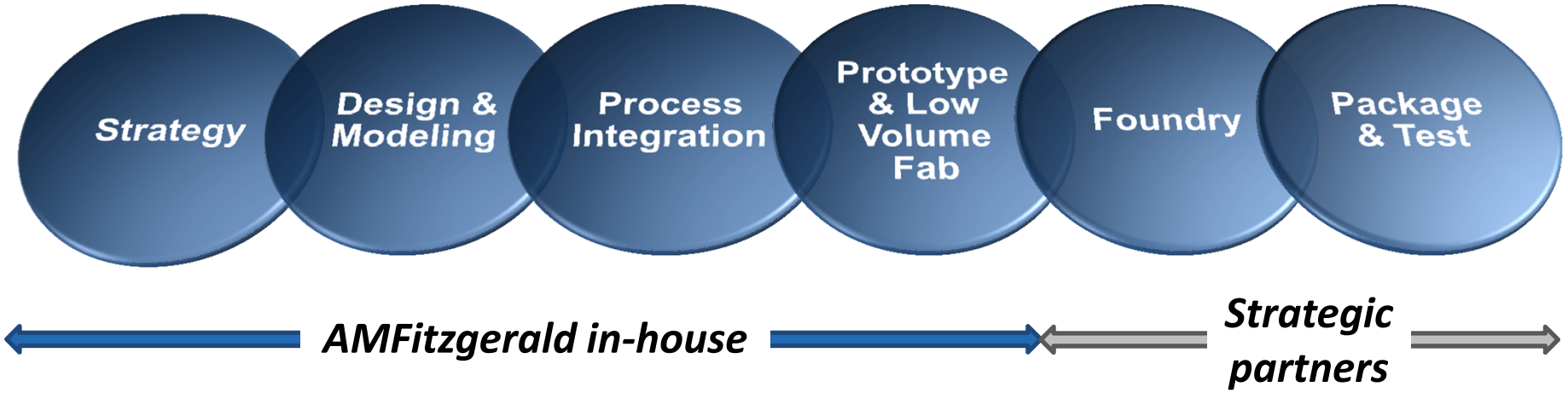
Company background

- **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

Full development services from concept to production

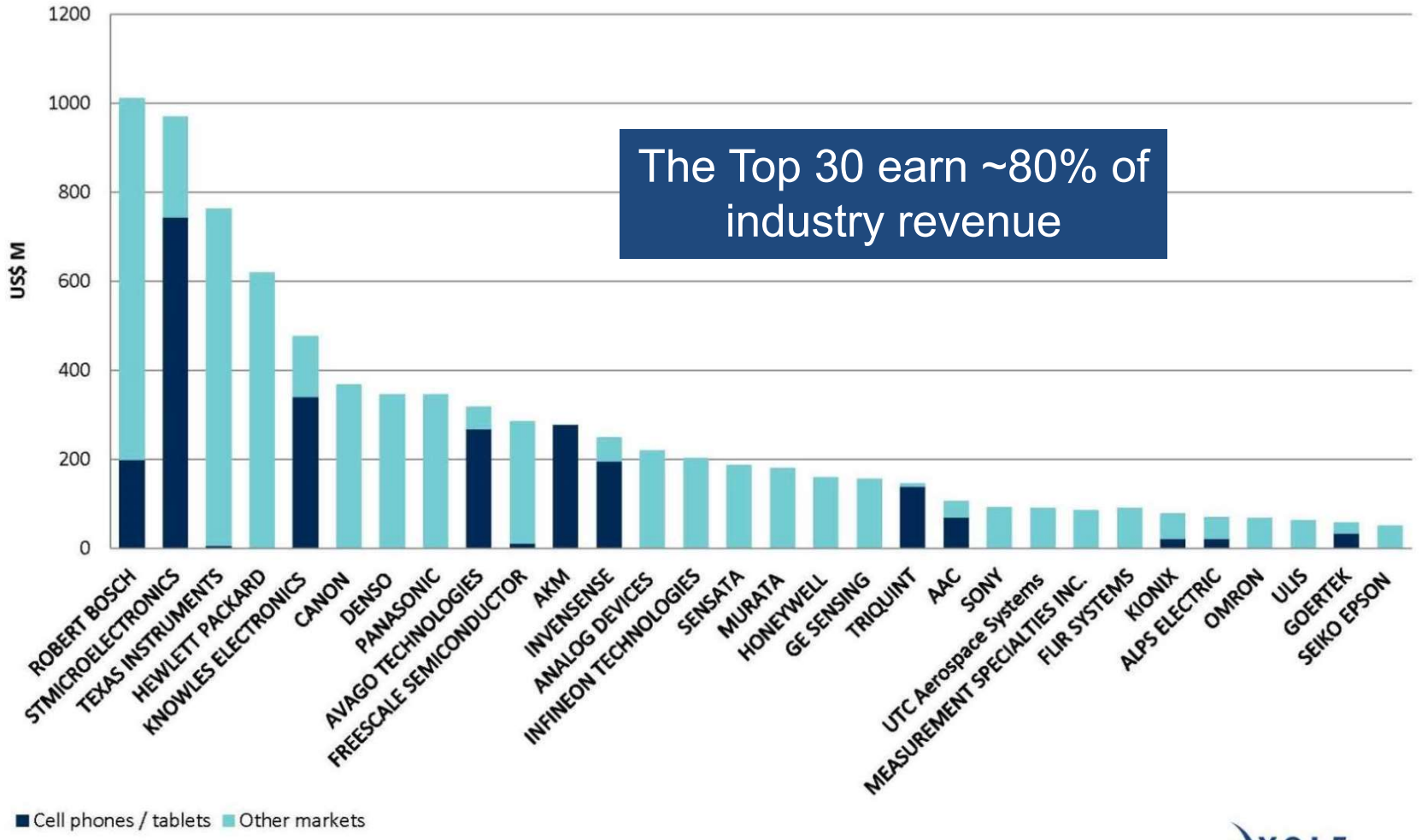


- **Custom MEMS development from start to finish**
  - **Multi-disciplinary, expert engineering team**
- **Design and process integration for volume production**
- **In-house prototype fabrication, easy transition to production partners**

A Tale of Two MEMS Markets

Top 30 MEMS Players with a focus on cell phone & tablet revenu - 2013 Revenue

(Source: MEMS & Sensors for Mobile Phones & Tablets, June 2014)

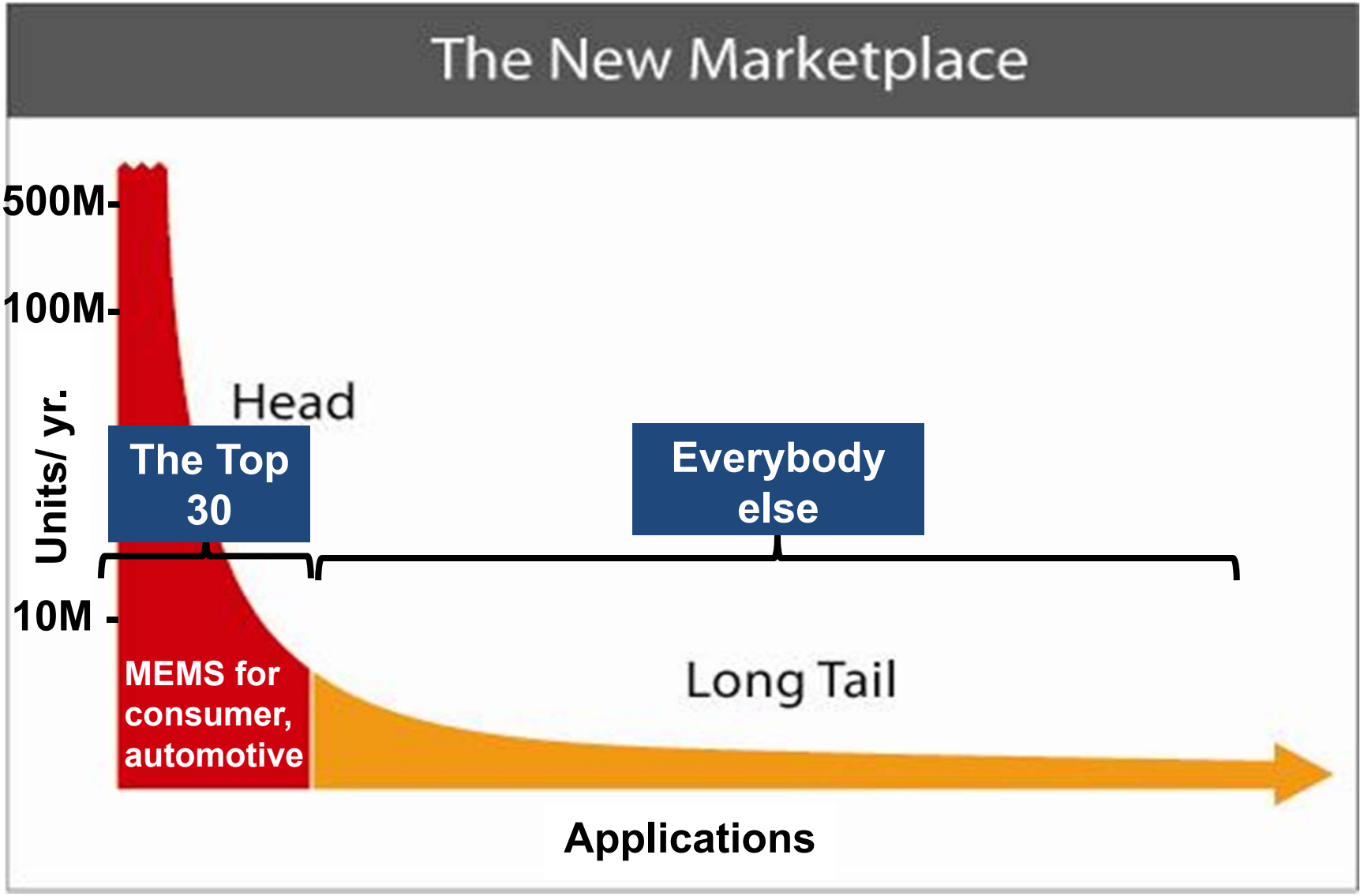


The Top 30 earn ~80% of industry revenue

The Long Tail concept of market distribution

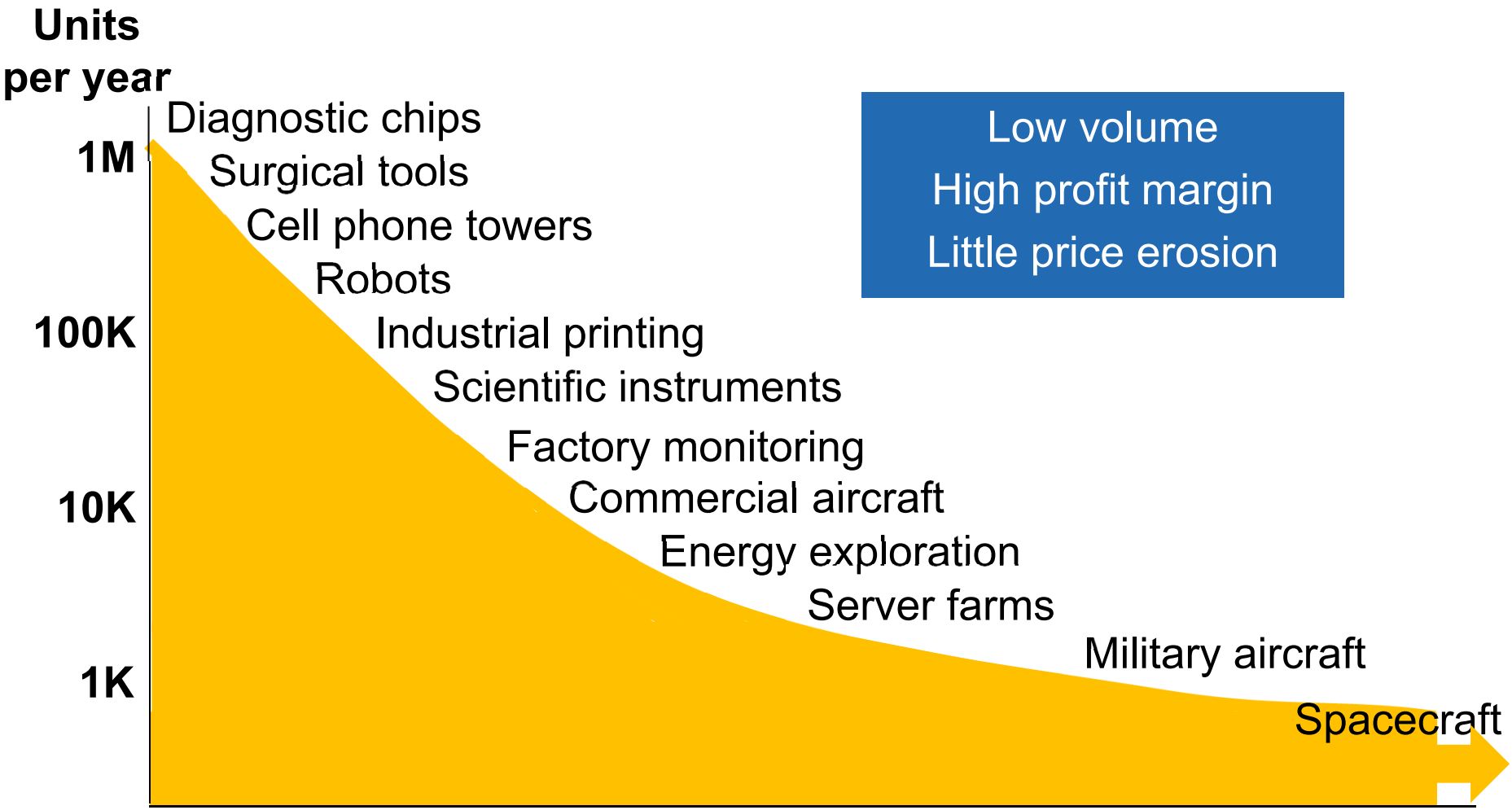
[Source: C. Anderson, Wired, October 2004.]

The MEMS Industry has a Long Tail



[Source: C. Anderson, Wired, October 2004.]

Some applications in the MEMS Long Tail



Long Tail company profile

- **A well-established system integrator or OEM**
  - **Has a mature product line**
  - **Deeply understands their market**
  - **Examples: Schlumberger, Medtronic**

- **Sees MEMS as an opportunity to make new products and gain a competitive advantage**
  - **New sensing capabilities**
  - **Lower existing product cost to expand market**

- **Sees market opportunity, needs < 2 years development to enter market at right time**

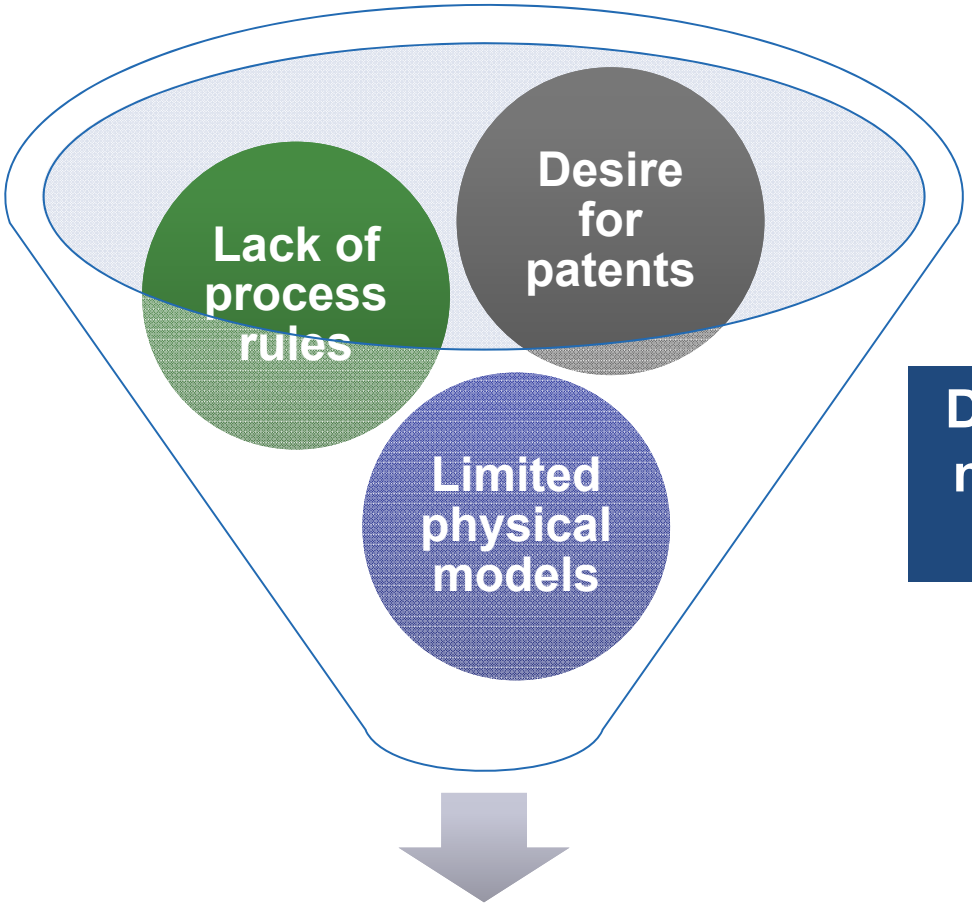
Long Tail company profile - continued

- **No experience with MEMS chip design or integration**
  - **No confidence nor desire to hire a MEMS team or to develop MEMS capabilities (yet)**
- **Views MEMS as a component in their system**
  - **Developing new patents not that important**
  - **IP is in package and system integration**
- **Would prefer to buy finished MEMS chips to minimize overall product development risk**
- ***Does not understand why MEMS development takes so long and is so risky!***

How to serve the Long Tail market

- **Serving the Long Tail requires selling many different items in small unit volumes**
- **Amazon is the master of the Long Tail market**
  - **Super-efficient operations model**
- **Current barriers in MEMS:**
  - **Long development times (usually 5+ years)**
  - **Hard to recover cost of custom development when unit volumes are so low**

The challenge of MEMS development



Designer forces new process to foundry

“One product, one process”

Jean-Christophe Eloy, Yole Développment

Current MEMS fabless model → design-fab-test cycles

Digital ASIC Fabless Model

Reference designs, IP blocks	Verified physics models	Foundry-specific design rules	Process modeling	Design simulation	Rule checking, Verification

New Design → **18 months, 95+% yield** → Product

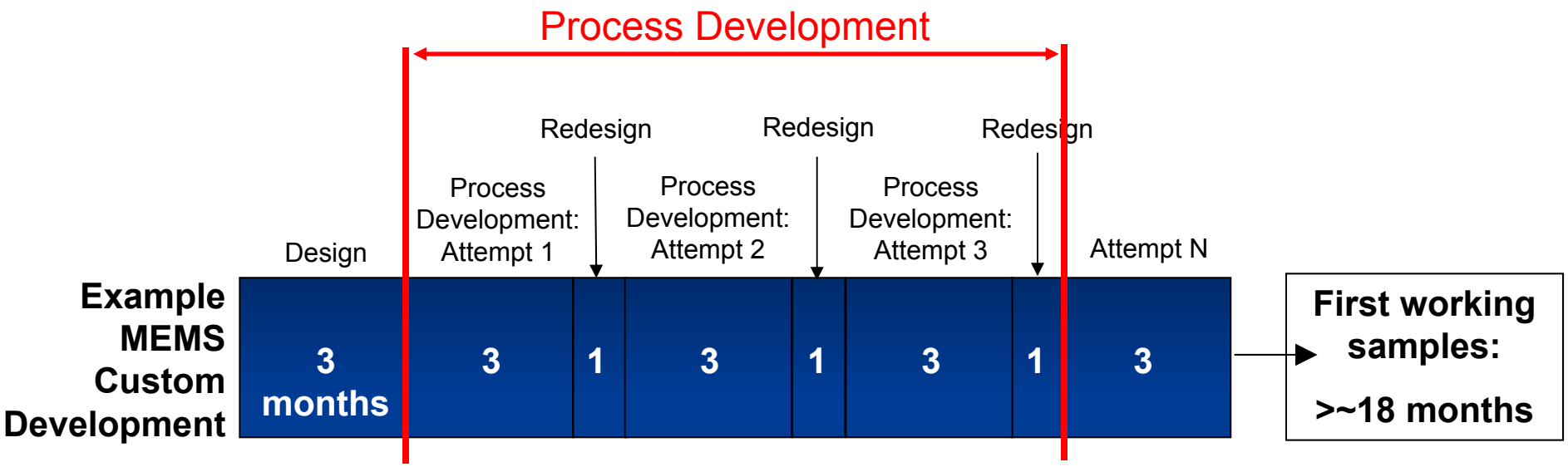
MEMS Fabless Model

Reference designs, IP blocks	Verified physics models	Foundry-specific design rules	Process modeling	Design simulation	Rule checking, Verification

New Design → **5+ years, ?% yield** → Product

GOOD | FAIR | POOR

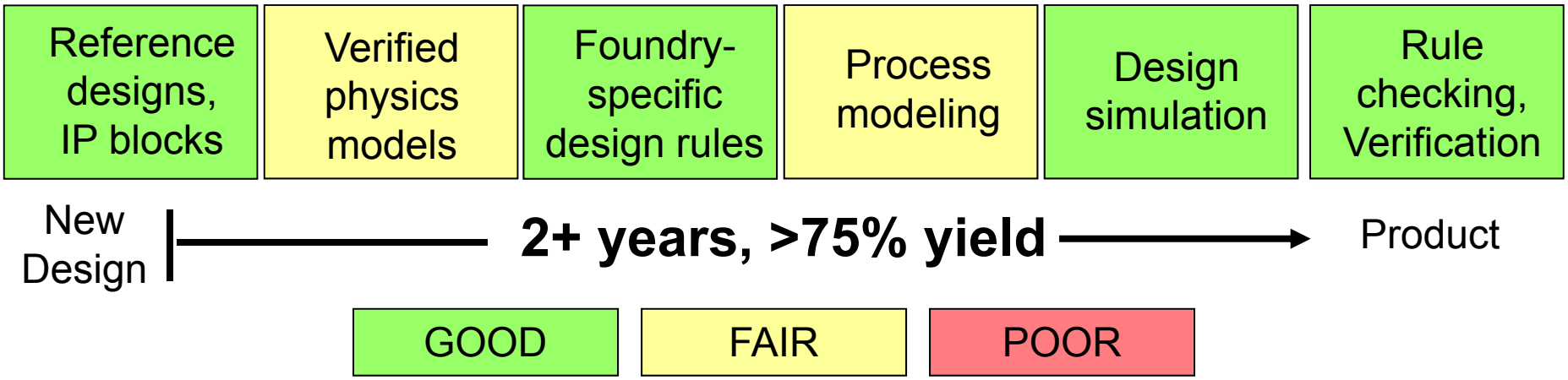
Process development consumes a lot of time



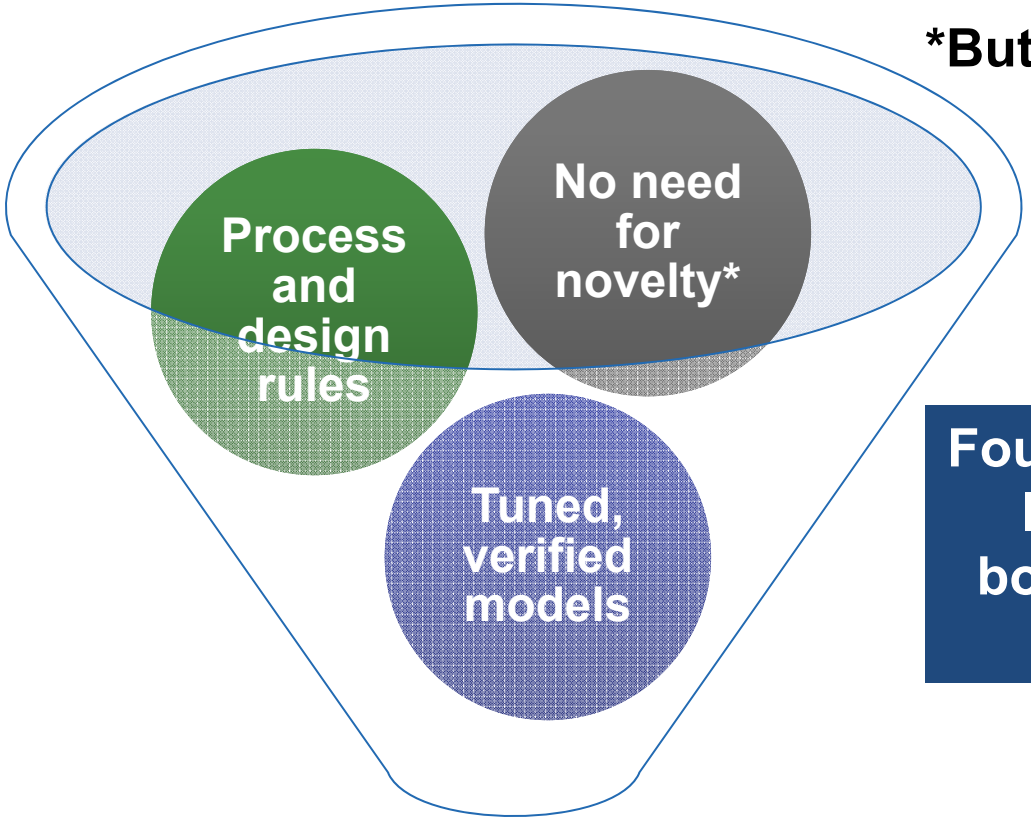
It's a different story for the Top 30 MEMS companies

- **They own their fabs and have characterized their processes**
  - **Mature process libraries, design rules**
  - **Customized EDA tools, IP blocks ("cells")**

Captive Fab MEMS Development



Letting process drive MEMS design



*But customization is desired!

Foundry process library sets boundaries for designs

One process <u>library</u>, many products…rapidly

Why can't MEMS copy the CMOS fabless model?

CMOS

- Process flow fixes Z axis
  - 2D design of circuits → many chip types
- Many ASIC designers

- CMOS foundry strongly motivated to create standard process flows
  - TSMC, GF, etc.

MEMS

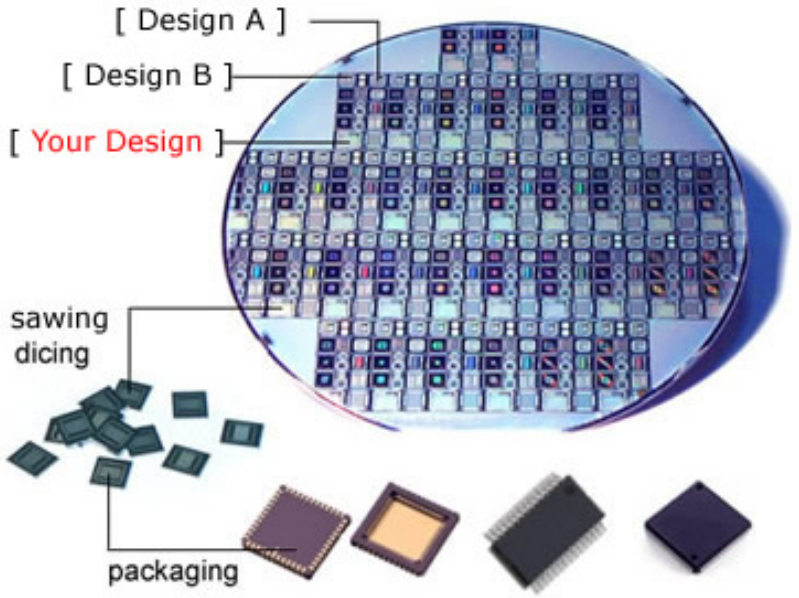
- Needs 3D design freedom
  - Process flow fixes Z axis → few sensor types
- Few MEMS designers

- MEMS foundry has *little* motivation to create standard process flows
  - Contract mfg. model

What about MEMS "Platforms"?

- **Mature process flows opened to public**

- **Customer must provide the chip design**
  - **Most Long Tail companies cannot provide a design!**



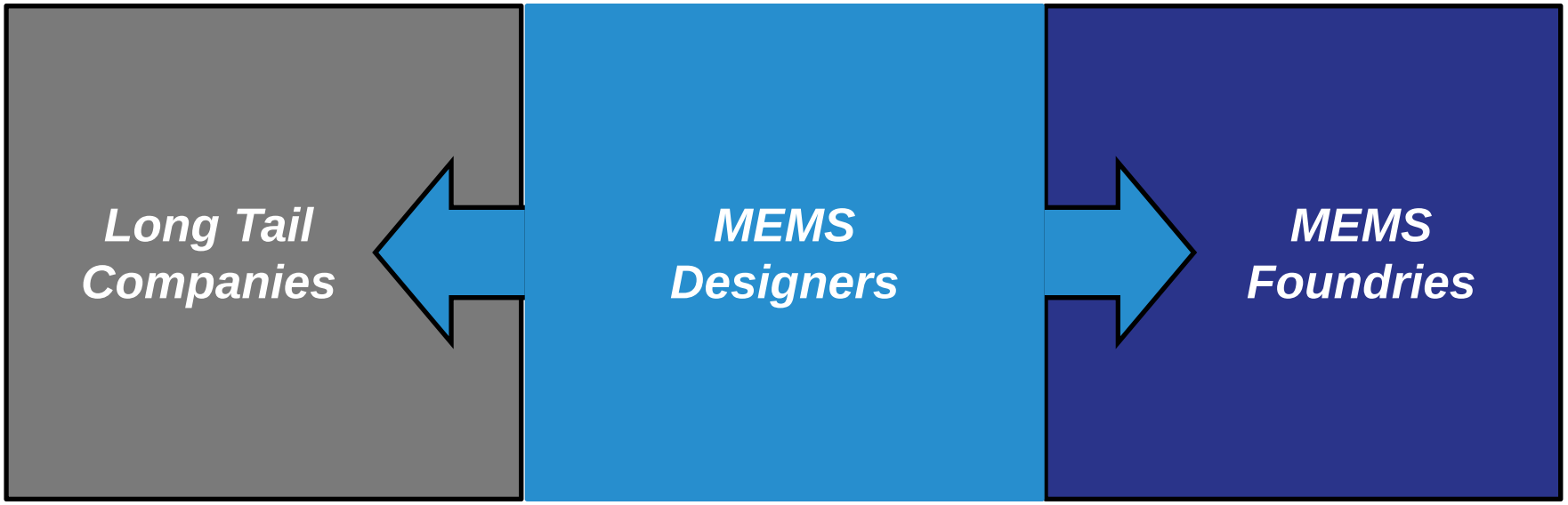
Source: CMP

Some MEMS platforms:

Facility	Service Name	Target Market	Process	Wafer size
ST	Thelma	Motion sensors	Thick epi-poly	200
Dalsa	MIDIS	Motion sensors	SOI with vacuum and pressure cavity	200
X-FAB	XMB-10	Motion sensors	Cavity SOI	150, 200
InvenSense	NF Shuttle	Motion sensors	CMOS cap, SOI wafer	200

Platforms are not effective without MEMS Designers

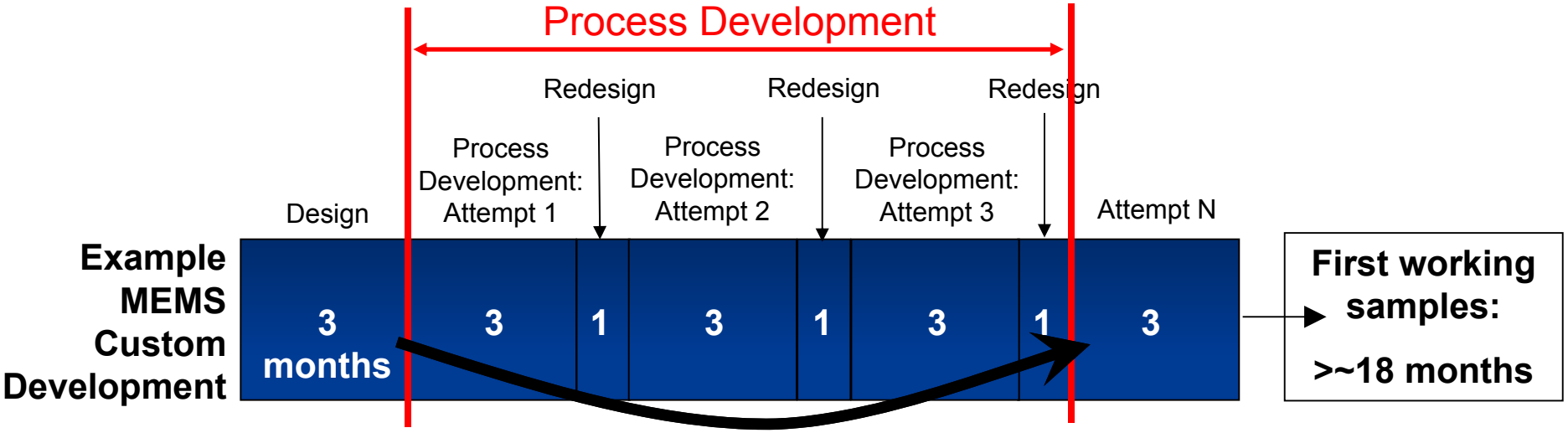
- There are very few of us!
  - MEMS is introduced very late in engineering education
  - Graduate-level only, usually Ph.D.
- Lack of full-featured design tools means experts must do design



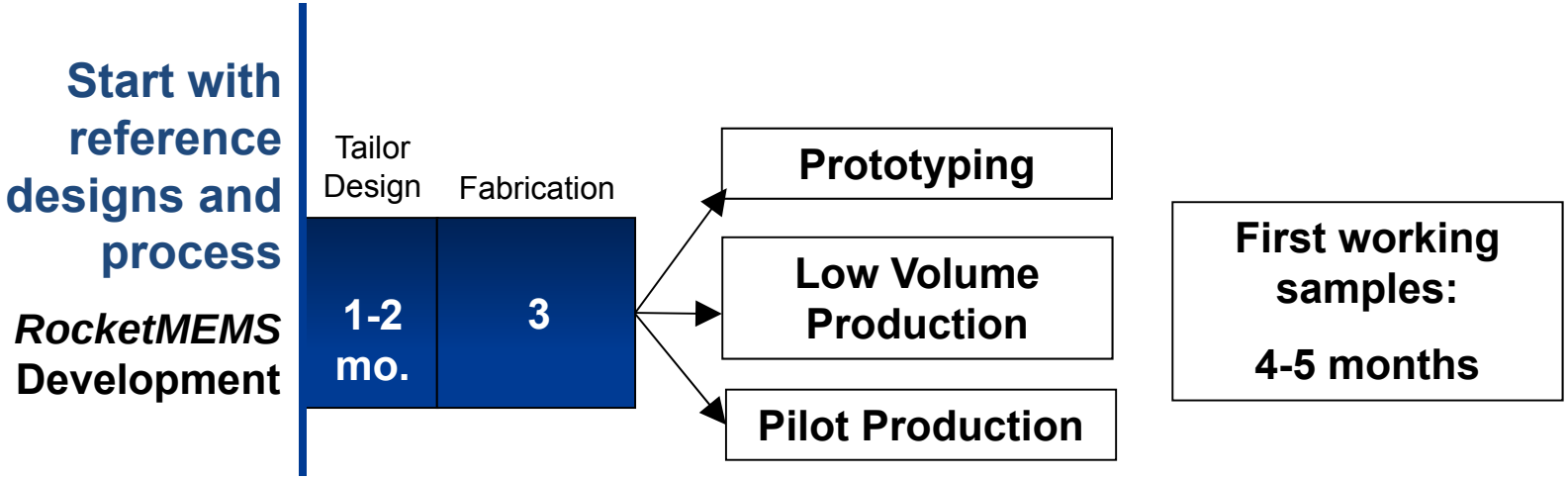
RocketMEMS: A Model for Designer-Foundry Cooperation

- **Designer and foundry define design/process together**
- **Use stable, characterized process modules**
  - **Silex SmartBlocks™ library**
- **Collaboratively assemble process flow from modules**
- **Create reference designs relevant to market needs**
  - **Many, but not all, sensor needs may be met**
- **Ownership:**
  - **Designer owns reference designs**
  - **Foundry owns process library**
  - **Customer gets silicon – fast!**

RocketMEMS® vs. Custom Development



RocketMEMS: Skips Process Development

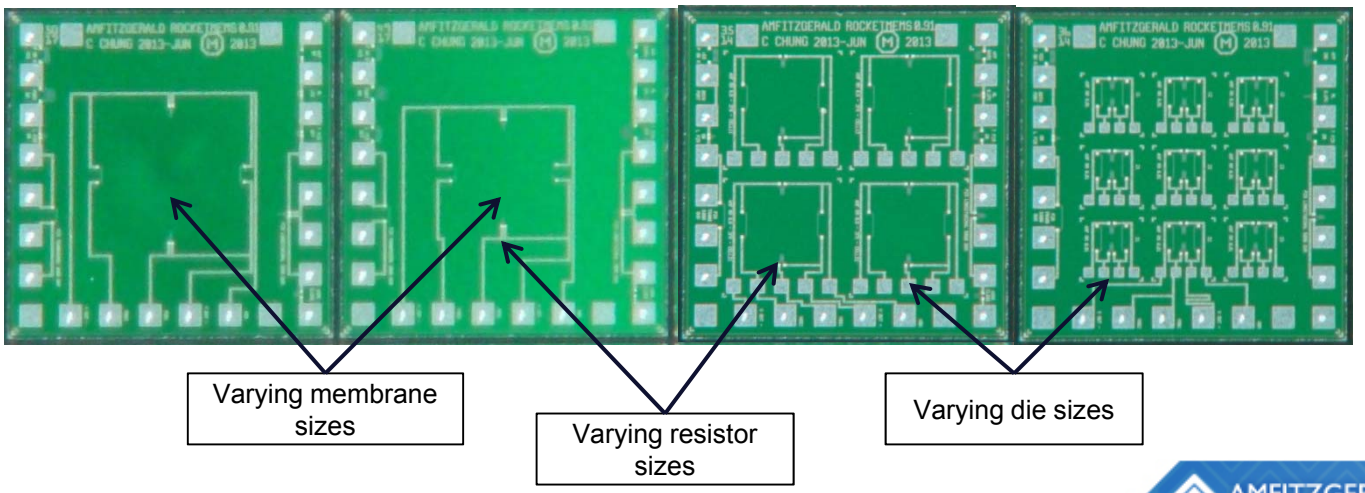


First *RocketMEMS* sensor type: Pressure

What can be customized?

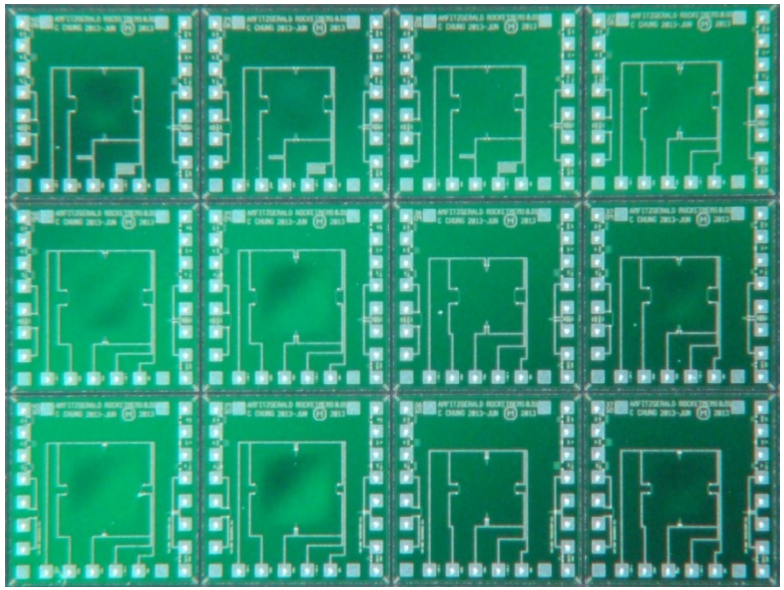
- **Pressure range**
- **Sensitivity**
- **Die size & thickness**
- **Bond pad location & size**
- **Bridge resistance**
- **Full vs. Half bridge**

Examples of various *RocketMEMS* pressure sensors
(with test structures)



Economical production that scales

- **Multi-Project Wafer (MPW) format for cost saving**
  - **Multiple customers served by AMFitzgerald**
- **Production options at different volumes**
  - **Prototype**
    - **500+ die**
  - **Low volume production**
    - **10,000+ die**
  - **High volume dedicated runs at Silex**
    - **100,000+ die**



Multi-Project Wafer: Many different chip designs are processed on the same wafer

RocketMEMS: Our philosophy

"Design for Verified Process"

- No process development
- Use proven reference designs and tailor them to customer specification

- Our long-term vision for RocketMEMS:
  - A menu of sensor types and foundries to suit a wide range of customer needs

Summary

- **Two MEMS industries: the Head and the Long Tail**
  - **Good business opportunities exist in the Long Tail – if one can serve it efficiently**
- **New models are needed to speed up MEMS development and serve the Long Tail**
  - **RocketMEMS is a new model – evolved from the ASIC design house model**
- **The RocketMEMS model can benefit the entire industry**
  - **Helps to grow the MEMS Fabless model and ecosystem**
  - **Connect OEMs/System Integrators to rapid MEMS solutions**
  - **IoT, etc.**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