MEMS Packaging in Product Development

NCCAVS Webinar

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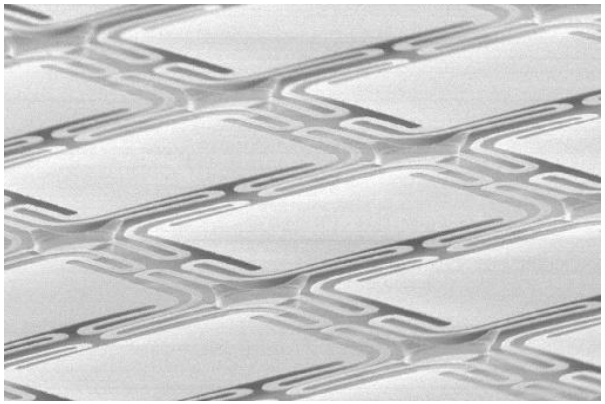
AMFITZGERALD
& ASSOCIATES

Overview

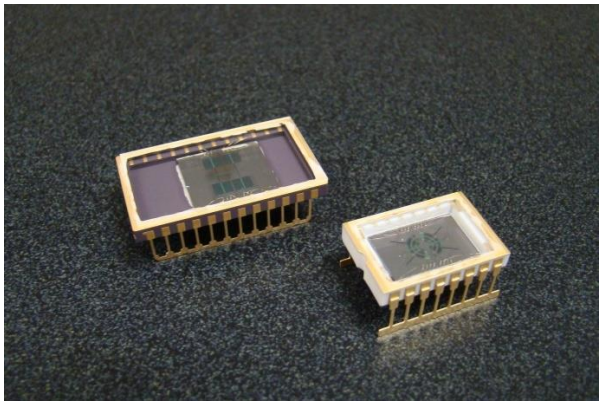
- About AMFitzgerald
- The journey of MEMS product development: planning for success
- Product requirements influence package choice
- MEMS package considerations
- Summary

AMFitzgerald: Your partner in specialty MEMS and microtechnology development

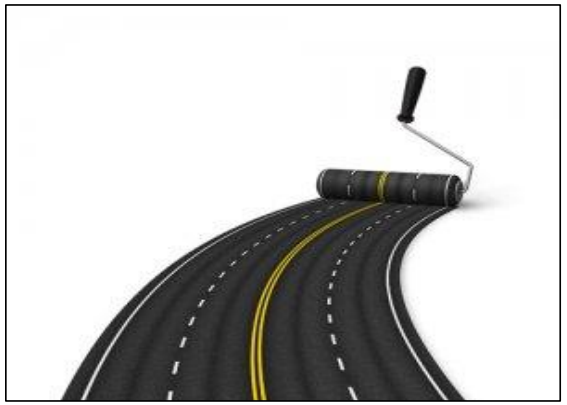
Innovation



Solutions



Strategy



AMFitzgerald develops innovative MEMS and sensor solutions for specialty applications.

We collaborate with our customers to create high value products enabled by customized microtechnology.

With integrity, expertise, and attention to detail, we deliver what has never been done before.

Our product development services get clients to production and to market

NASA Technology Readiness Level (TRL)

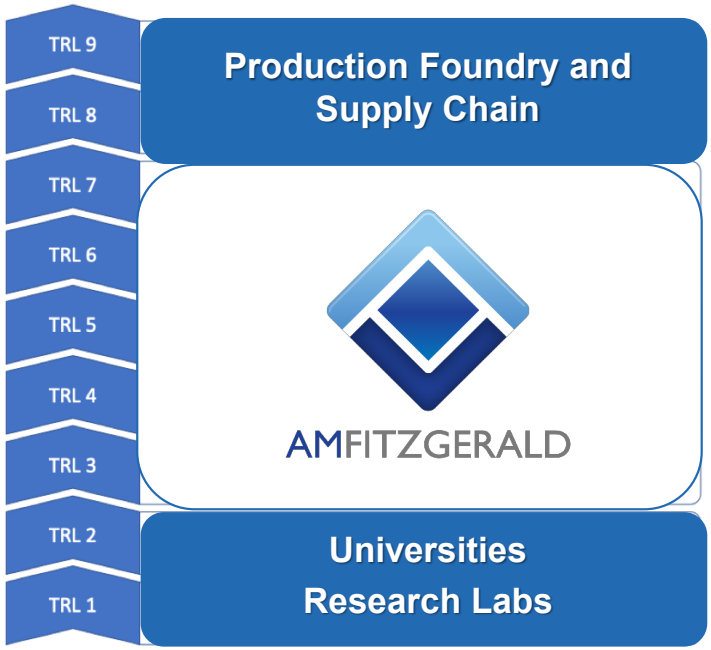
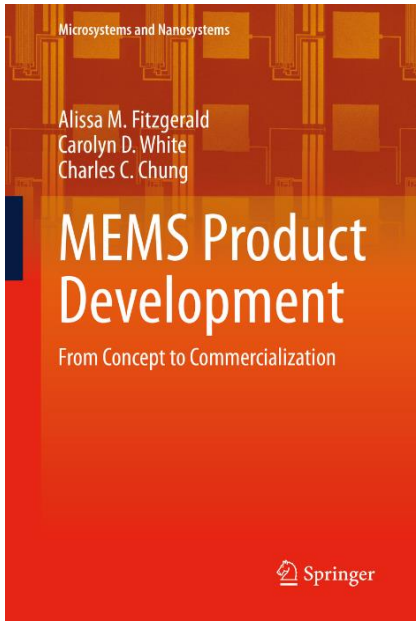


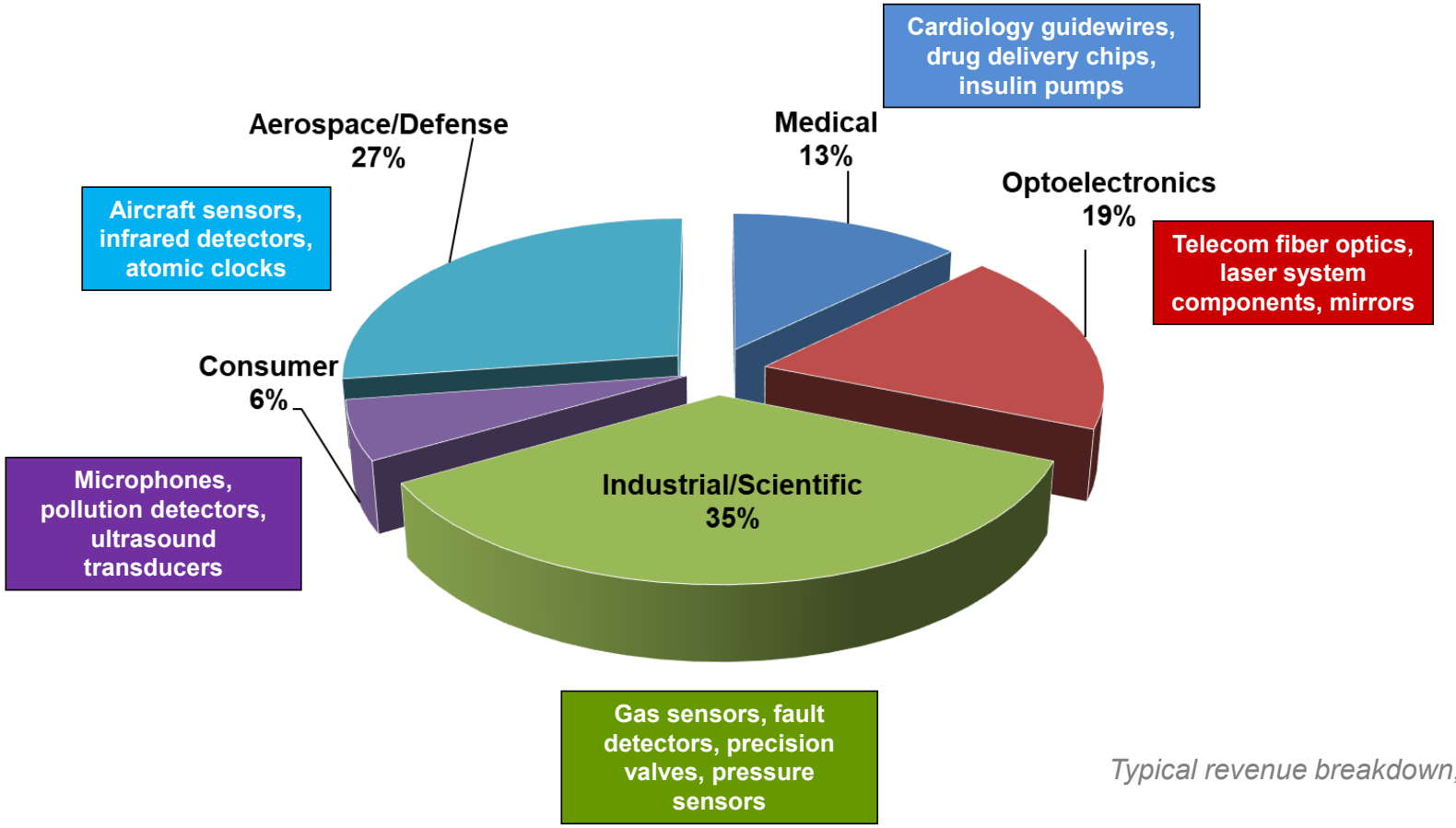
Image source

AMFitzgerald bridges the development gap (TRL 3-7)



The topics we are presenting today are covered more extensively in our book.

Our custom MEMS designs enable products in high value markets



Typical revenue breakdown, by market

A global business in MEMS product development

Headquarters in Burlingame, CA
5 minutes from SFO

150mm wafer fabrication by our staff at
UC Berkeley Marvell Nanolab

- **Company profile**
  - **Founded 2003, privately held**
  - **USA headquarters: Bay Area, near Silicon Valley**
  - **Facilities:**
    - **15,000 sq. ft. rented MEMS fab access**
    - **200 sq. ft. Class 100 cleanroom for test and measurement**

- **Over 400 projects completed to date, from startups to public multi-national enterprises**

AMFitzgerald client locations

The MEMS product development journey

Would you go into the wilderness without preparation? Many MEMS teams do.

Image: https://hiconsumption.com/best-survival-schools/

The #1 reason our startup clients do not advance to volume production is…

The technology usually works!

But it needs <u>a lot</u> of money and time to perfect.

Proper preparation prevents poor outcomes

- **Most common funding problems:**
  - **Funded for only one prototype run**
  - **Discontinuous funding**
    - **Work slowdown/stoppage for months**
  - **Unrealistic timelines for development**
    - **Funding runway is too short**
  - **Fixated on MEMS silicon component**
    - **Not enough budget reserved for package, electronics, software development**

- **How much funding do you need? First, properly scope the development**

What is the product? Requirements analysis

Start by understanding all product requirements

- **Early MEMS product development often focuses on just the MEMS chip**
  - **Especially when technology originates from academia or at early startups**
- **Components which are critical to product viability:**
  - **Chip package**
  - **Assembly method and yield**
  - **Calibration**
  - **Control and readout electronics**
  - **Software**
  - **Specialty items such as: Regulatory compliance, thermal management, etc.**
- **All requirements must be met, and at the right cost**

Whose requirements are important to your product?

Selling a MEMS component into a complex system product (e.g. automobile)

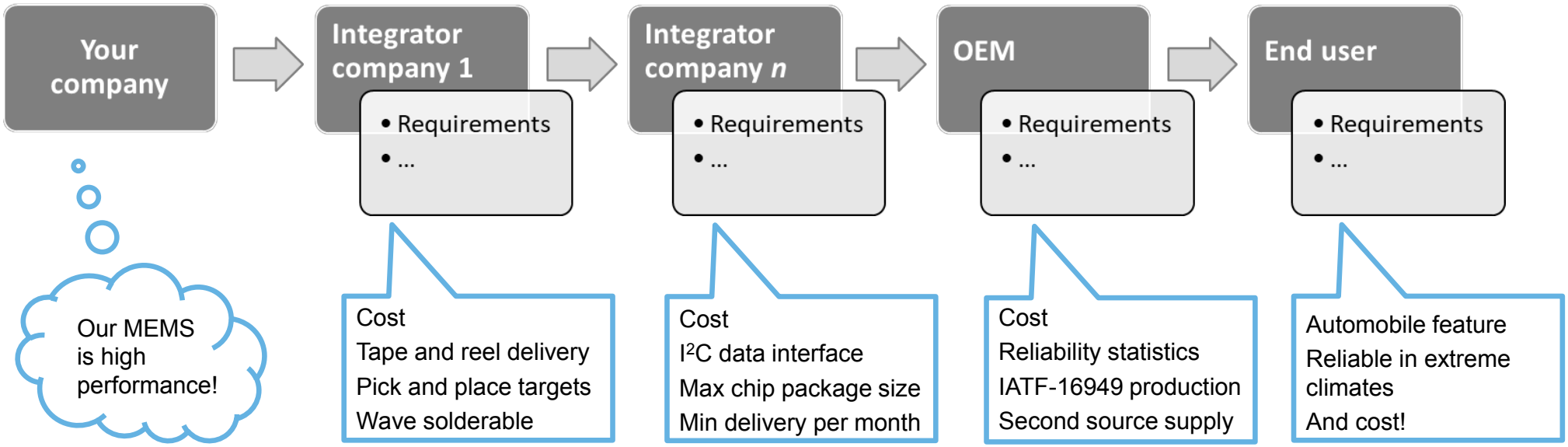


Figure 4.2 *MEMS Product Development*

Investigate interface requirements to avoid costly MEMS chip re-designs

Interface Item	Example Risk	Severity and Consequence	Impact to Development
Packaging	MEMS chip layout does not include correct fiducials, bondpads, etc. for selected COTS package	Medium; redesign of masks and re-process wafers or need for custom package	Delay: 2–4 months Cost: $50–300K
Operating voltage	System electronics do not supply correct voltage; MEMS device will not function as well as intended or at all	Medium; redesign of electronics and/or MEMS device for compatible voltage operation	Delay: 2–4 months Cost: $50–300K
Actuator	MEMS actuator does not provide enough force for system function	High; complete re-design of actuator and process	Delay: > 6 months Cost: > $500K

Table 8.1 *MEMS Product Development*

Cost models illuminate how tech specs influence unit cost – and profitability

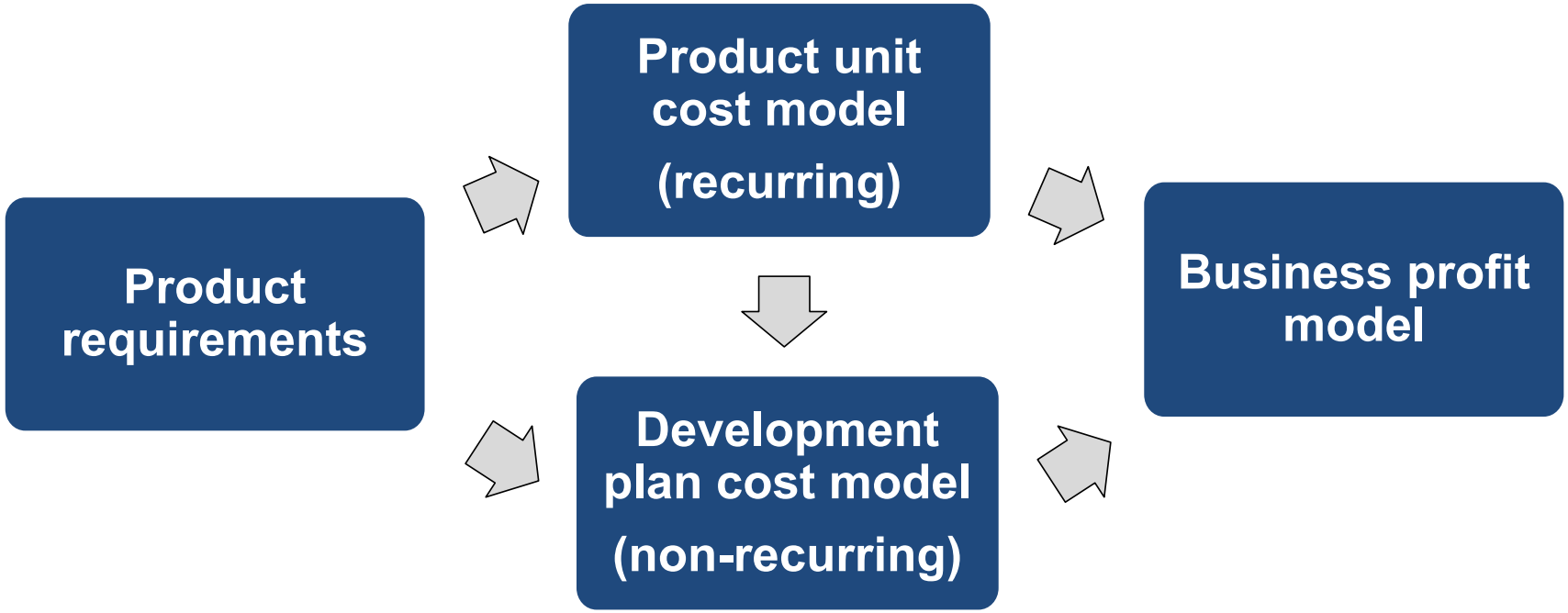


Figure 4.1 *MEMS Product Development*

MEMS Packaging

A MEMS product is a system of components – and the package is one

- **Functions provided by the package (cross-section view)**

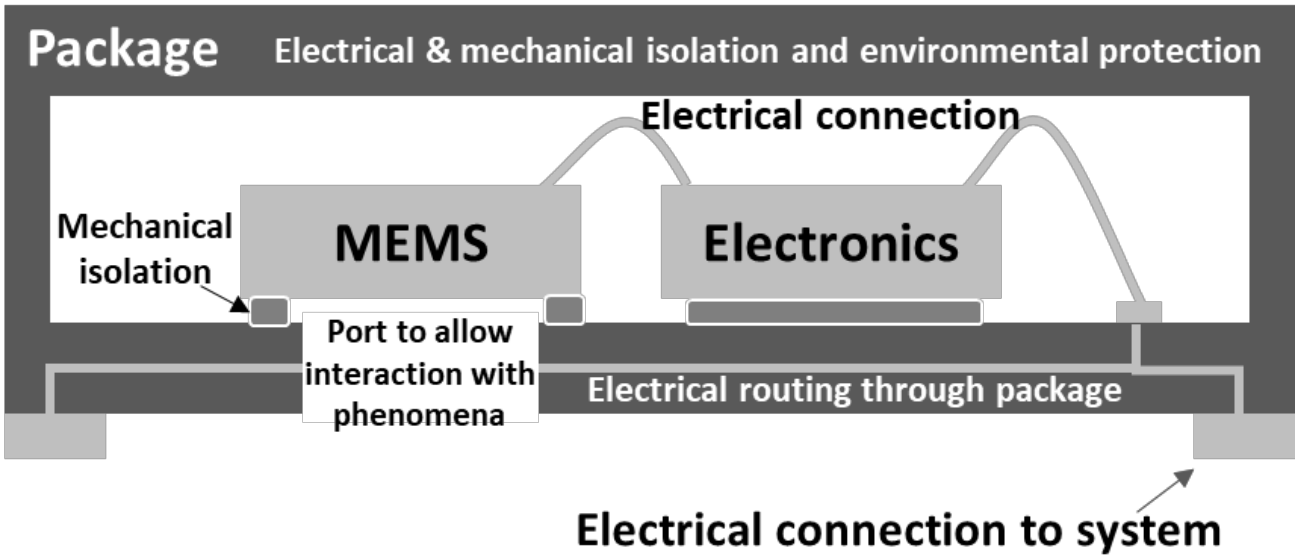
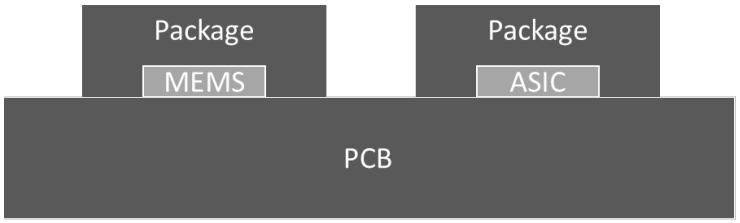
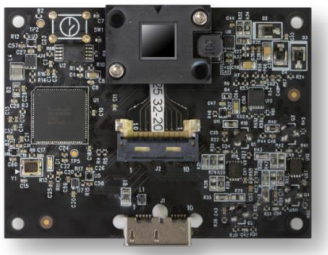


Figure 9.2 *MEMS Product Development*

Levels of integration determine package requirements

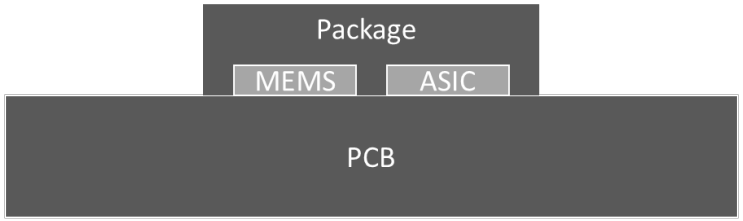
“Board level”

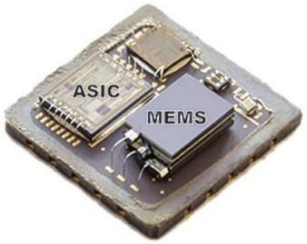




Source: Unispectral Ltd.

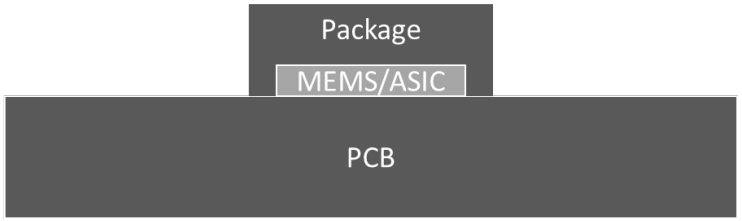
“Package level”





Source: Colibrys MS9000-series accelerometer

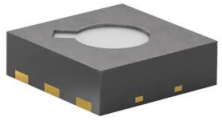
“Chip level”



Source: TDK InvenSense

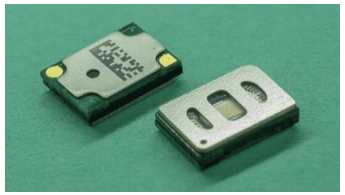
Figures 9.4, 9.5 *MEMS Product Development*

A wide variety of end-use requirements and package types

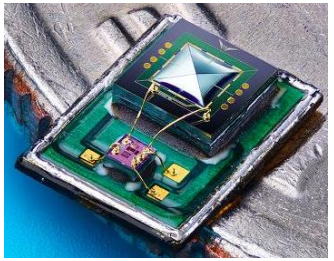


Sensirion gas sensor

Bosch combo environmental sensor



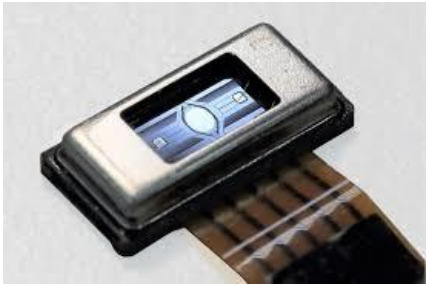
USound microspeaker



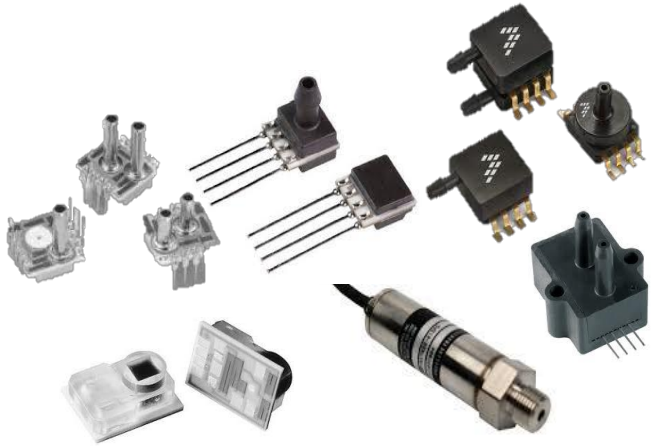
Vesper microphone

TI DLP

ADI combo inertial measurement unit



Ultimems 2D scanning mirror



GE and Freescale pressure sensors

Package type contributes to product unit cost

MEMS products (examples)	Package Technical Requirements	Package Type	Relative Cost of Package
Inertial sensors, resonators, filters	High-volume, low cost packaging method for robust MEMS chips	Plastic overmold, such as quad flat no-leads (QFN)	Low
Microphones, microspeakers, pressure sensors	High-volume packaging method	Plastic molded case, with aperture	Low
Gas sensors, bolometers	Stiff package that tolerates higher temperatures, chemically resistant	Ceramic open cavity with lid	Medium
Micro-mirrors, electrostatic switches	Stiff package that tolerates higher temperatures; laser-welded lid to seal in nitrogen or argon atmosphere that provides gas damping	Ceramic open cavity with lid and controlled atmosphere	High
Sensors and actuators for radiation environments in aerospace, military, or medical applications	Specialty package, custom order	Ceramic, radiation hardened	Very high

Definitions of relative cost in 2021: "Low" corresponds to less than US$0.10 per unit, sold in volume; "Medium" to less than US$1.00 per unit; "High" to less than US$10.00 per unit; and "Very high" to more than US$10.00 per unit.

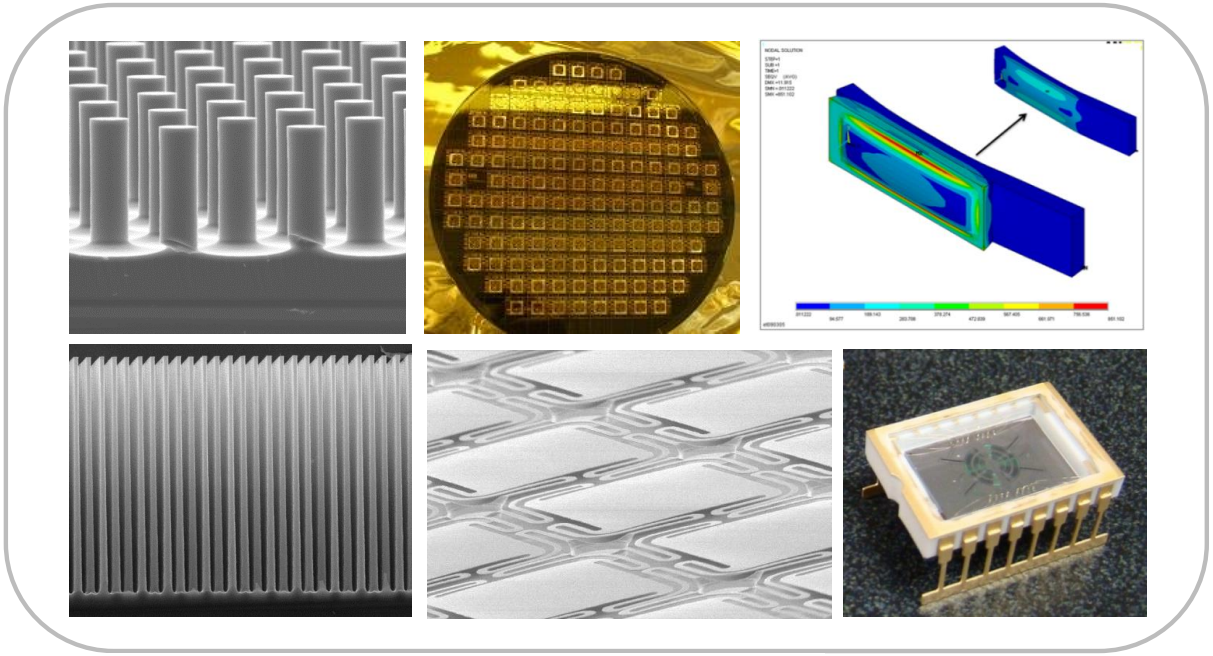
Excerpted from Table 4.3, *MEMS Product Development*

Summary

- **Seek to understand all product requirements, not just the transducer's**
- **The package is a key component in a MEMS product's viability**
  - **Using COTS packages will enable faster time to market**
  - **Design MEMS chip for its package**
- **Don't forget to include packaging, assembly and test costs in early unit cost models**
  - **These can be 75% of finished unit cost!**
- **MEMS are complex system products and take time to perfect**
  - **Be sure to have enough budget for development of the whole system**

Questions?

MEMS Product Development **available now in hardcover or e-book from Amazon (USA) or Springer (Int'l)**



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