

MEMS process integration and volume production

***JERWEI HSIEH, Ph.D.
Asia Pacific Microsystems Inc.***

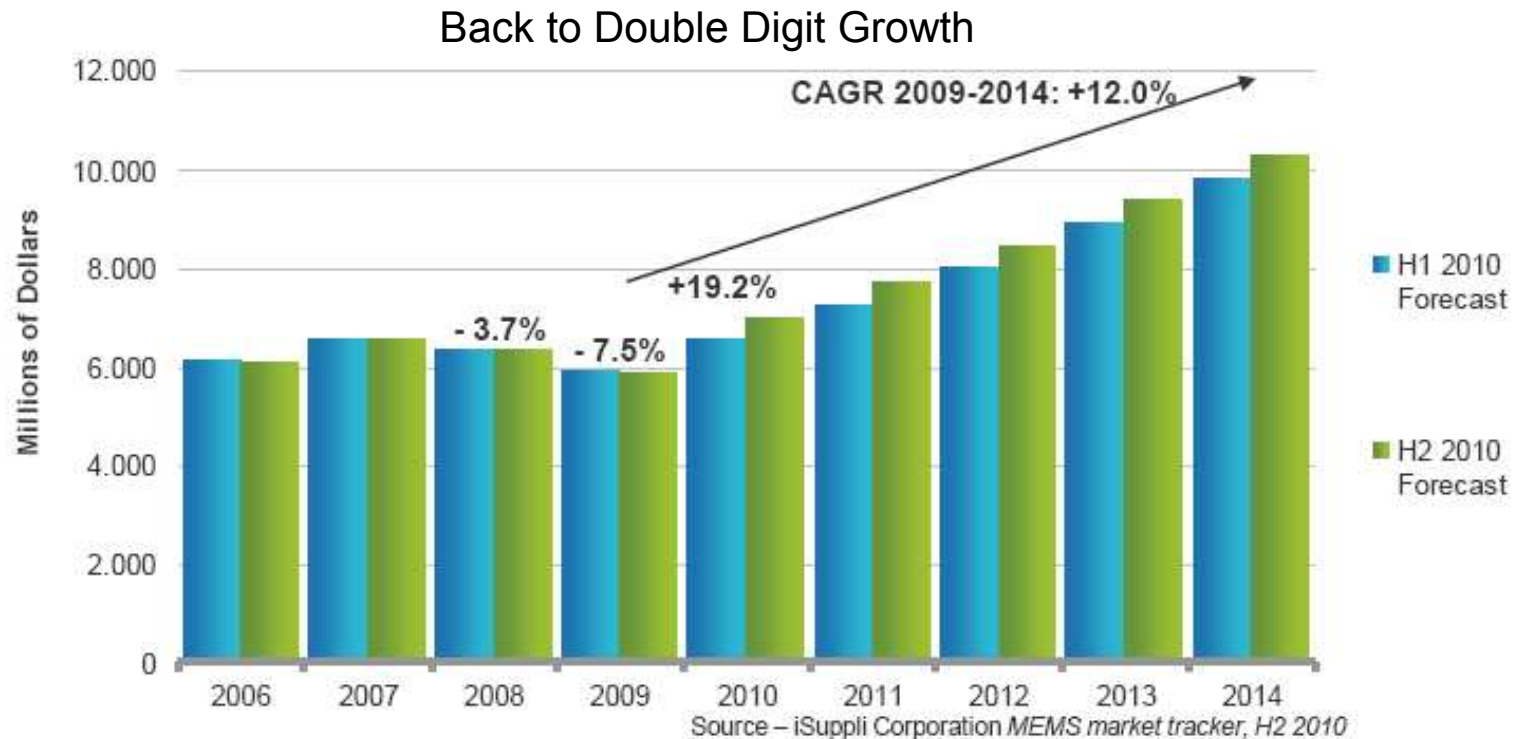
Jerwei@apmsinc.com

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Outline

- *Facts on MEMS Industry*
- *Volume Production in MEMS Foundry*
- *On Expediting Prototype to Market*

MEMS industry is growing



► „After the crisis effect“

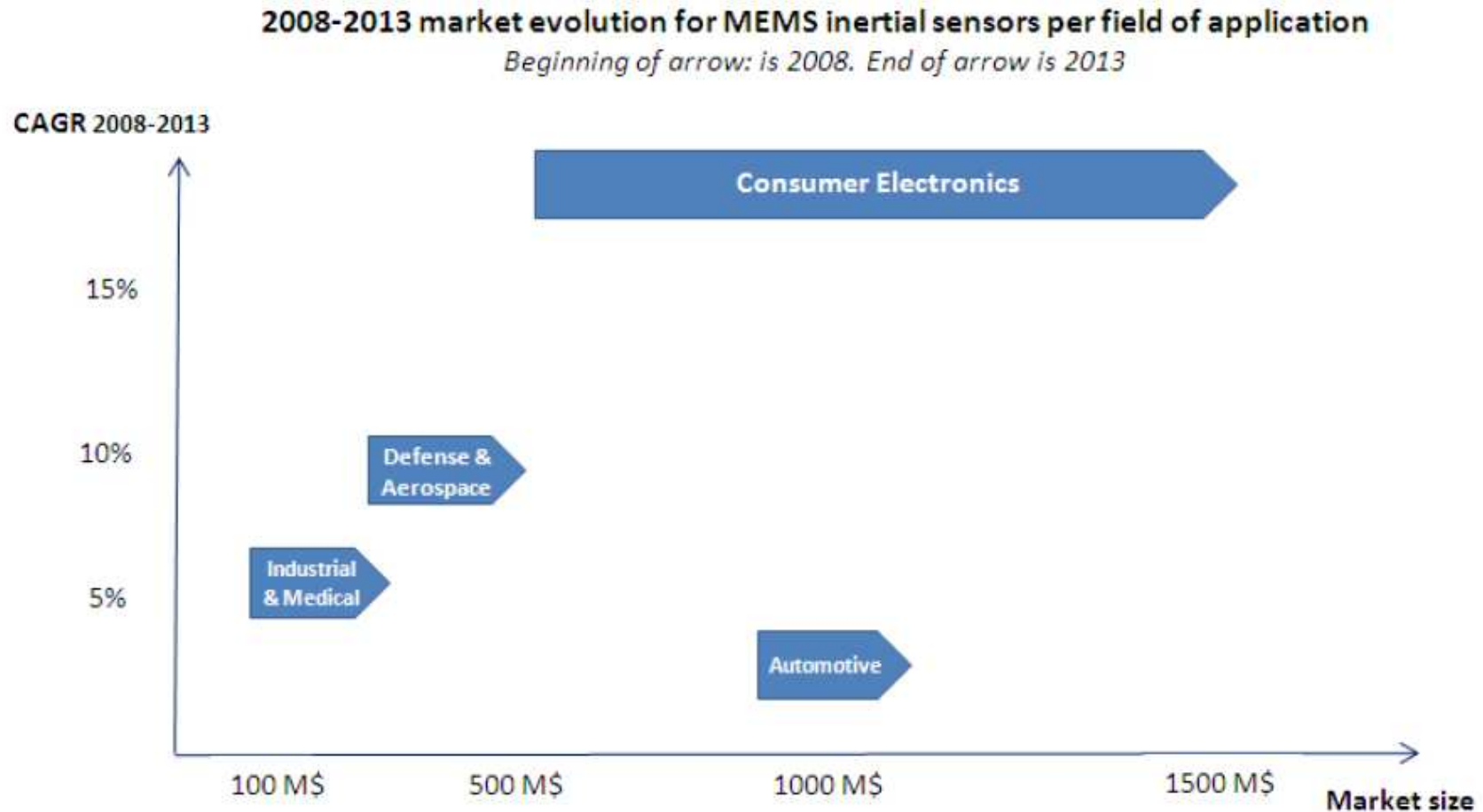
- Rebuilding inventory e.g. in automotive: +27% in revenue in 2010
- MEMS wafer probes for memory market: +50% in revenue in 2010

► Independently from crisis

- iPhone 4 and iPad effect
- Pico-projetor boom
- BRIC countries demand for MEMS for automotive, education, infrastructure...

Source: iSupply, Nov/2010

MEMS industry is growing



Source: Yole, MIG, Nov 2010

MEMS industry is growing

■ *MEMS status:*

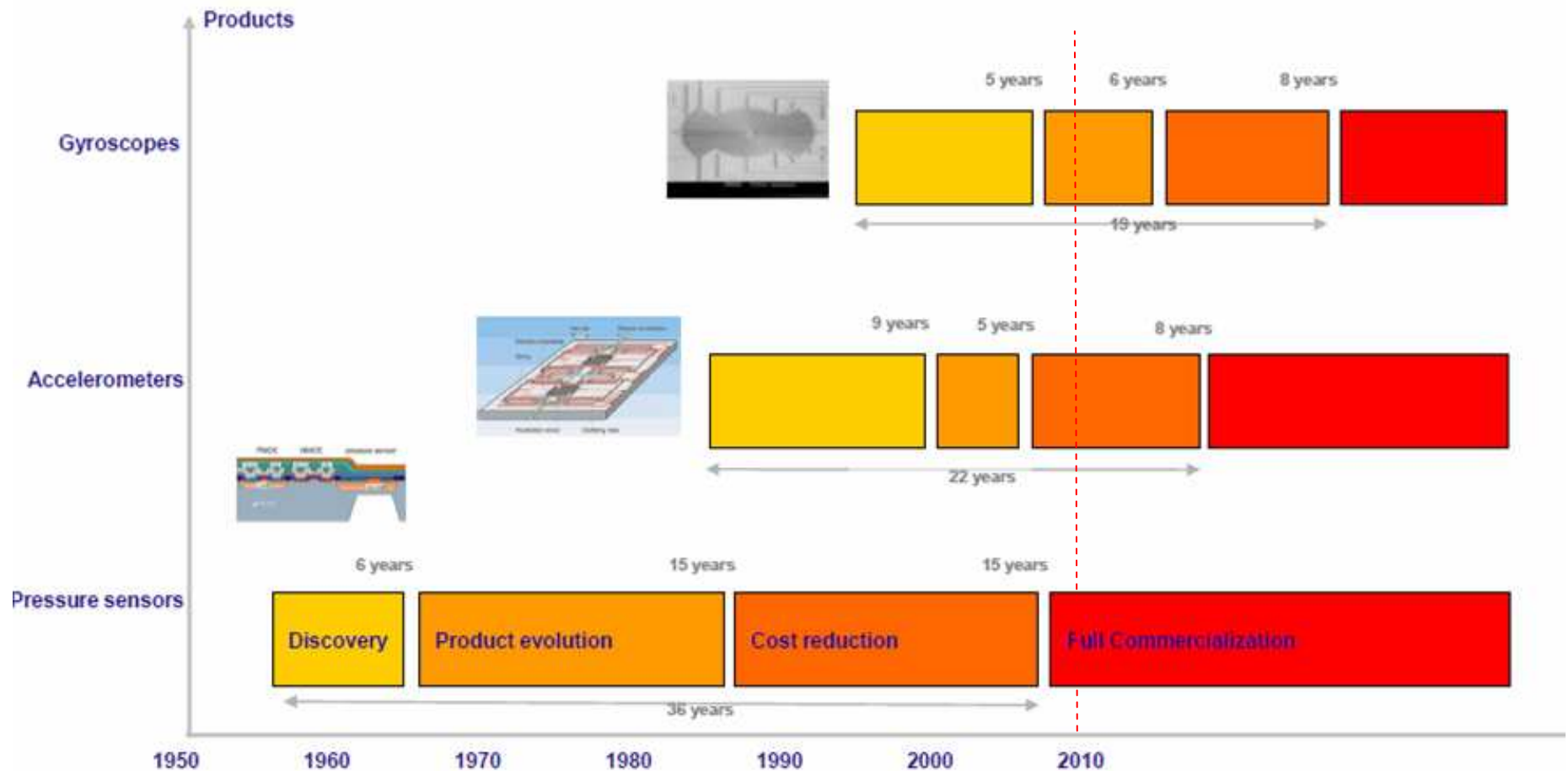
- *Robust growth in unit, higher than semiconductor in average, less cyclic. However, ASP is decreasing largely as well.*
- *MEMS share keeps increasing in the BOM of mobile handsets*
- *Number of fab-less MEMS companies is growing*
- *Most new MEMS product companies are following the fabless model due to matured foundry market and decreased VC funding*
- *Some system companies with MEMS fabs are looking to outsource their MEMS production.*

■ *More brand names:*

- *CMOS foundries such as TSMC, UMC, GlobalFoundries, SMIC are building massive capacity*
- *Legend MEMS foundries like Dalsa, APM, Microlyne... are recentered on higher value markets*
- *IC design house (Qualcomm, Mediatek, CSR, Maxim, IDT,...) are investigating how to step deeper in value chain and looking for good bargain for acquiring*

MEMS industry is changing

■ *MEMS development time is long?*



Source: Yole report, Mar 2010

MEMS industry is changing

- *Customers not well educated?*

2008 Beijing Summer
Olympic Games



3-axis gyro (angular velocity)
Pitch, roll & yaw
Rotation about gravity
Gyro + accelerometer provide
6-axis motion sensing
New CoreMotion APIs

<http://www.CNET.com/>



Source: Hornbeck, MIG, Oct 2010

MEMS industry is changing

- MEMS volume is still small?*

Billions of MEMS Devices

Avago	>2B	Since 2003	As of Q2 2010
Robert Bosch	>1B	Since 1995	As of Nov 2008
Knowles	>1B	Since 2003	As of Sept 2009
Texas Instruments	>1.4E16 mirrors	Since 1996	As of Dec 2009
ST Micro	>1B	Since 2006	As of Dec 2010
HP	"billions"		
Cepheid	~\$1B	Since 1996	As of Q4 2010

1980

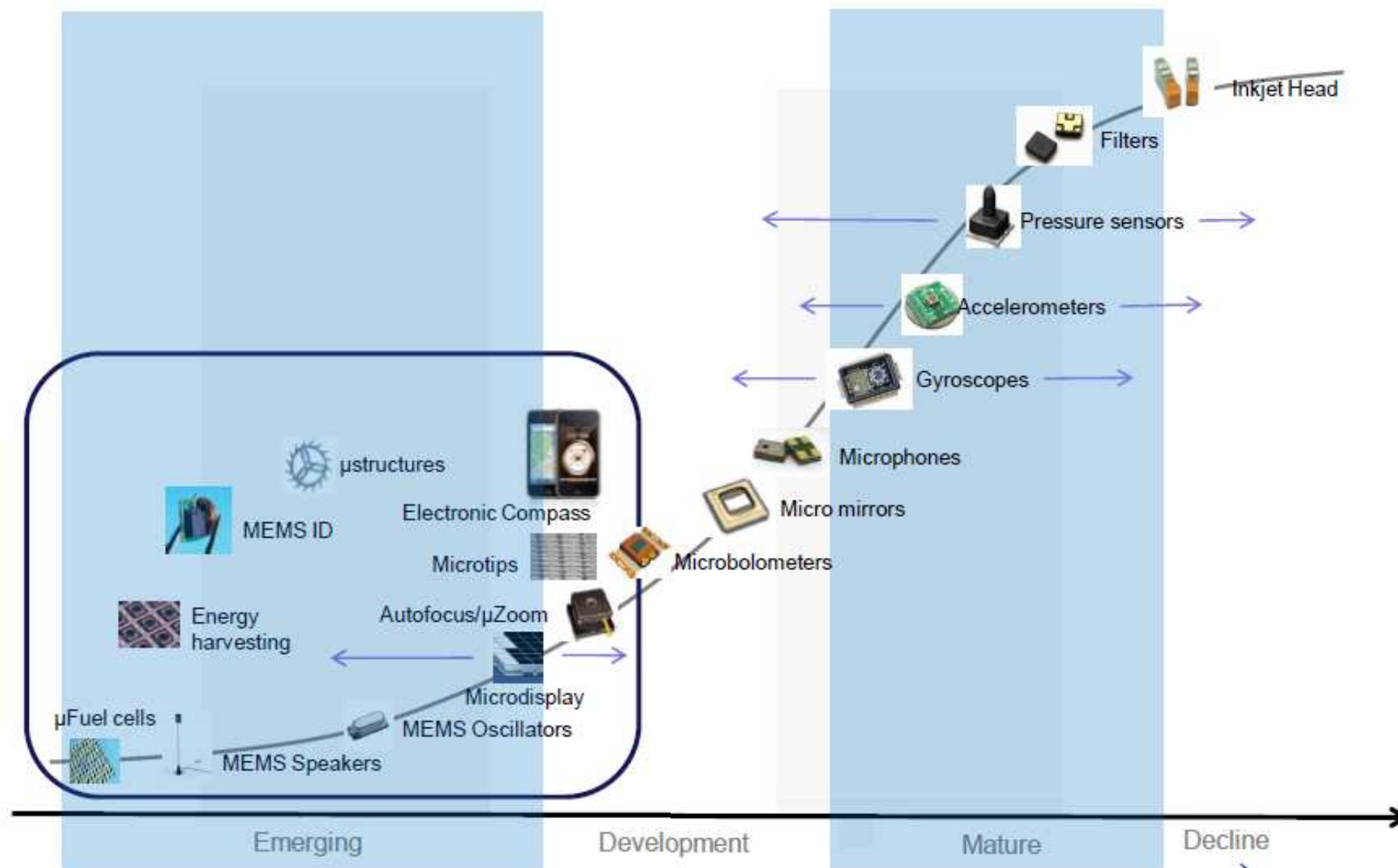
1990

2000

2010

But some remain unchanged

■ MEMS as a fragmented market



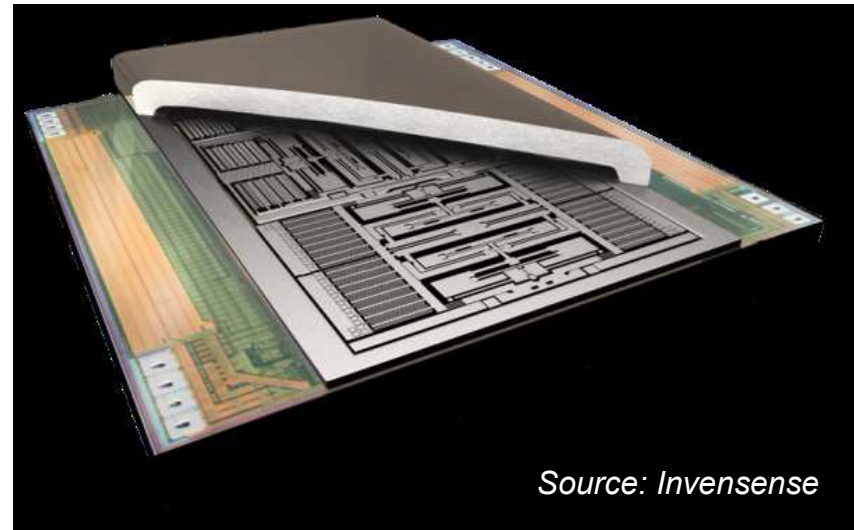
Source: Yole, MIG, Nov 2010

But some remain unchanged

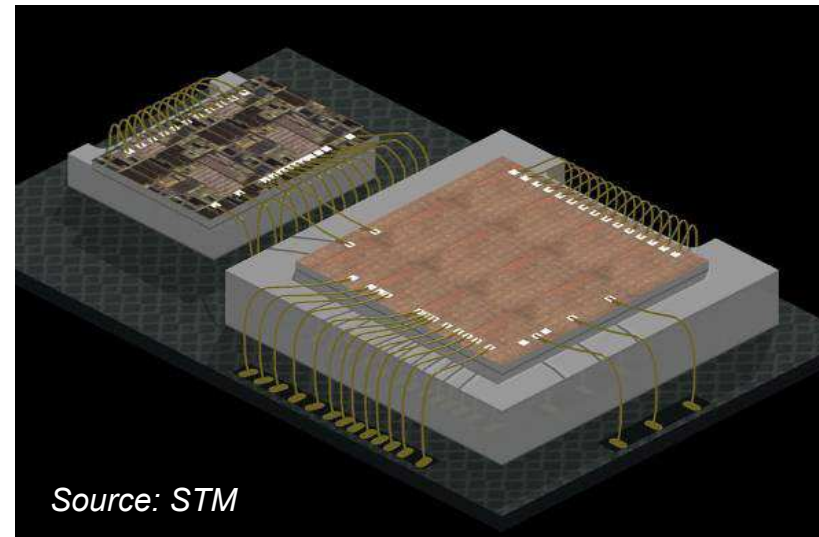
■ No MEMS platform can be broadly used

感測器供應商	加速度計	陀螺儀	壓力計	麥克風	振盪器
Alps Electronics			✓		
Analog Devices	✓	✓	✓	✓	
Akustica				✓	
Bosch-Sensortec	✓	✓	✓	✓	
Denso	✓	✓	✓		
Epson-Toyocom					✓
Discera					✓
Ecliptek					✓
Epcos				✓	
Freescale	✓		✓		
Gladiator Technologies	✓	✓			
Hewlett-Packar	(出樣中)				
Invensense	✓	✓			
Kionix	✓				
Knowles				✓	
Measurement Specialties	✓		✓		
Memsic	✓				
Panasonic	✓	✓	✓	✓	
Sensata Technologies	✓		✓		
Silicon Labs					✓
Sensoror Technologies		✓	✓		
SiTime					✓
意法半導體	✓	✓	✓	✓	
Vti Technologies	✓	✓			

資料來源：EE Times



Source: Invensense



Source: STM

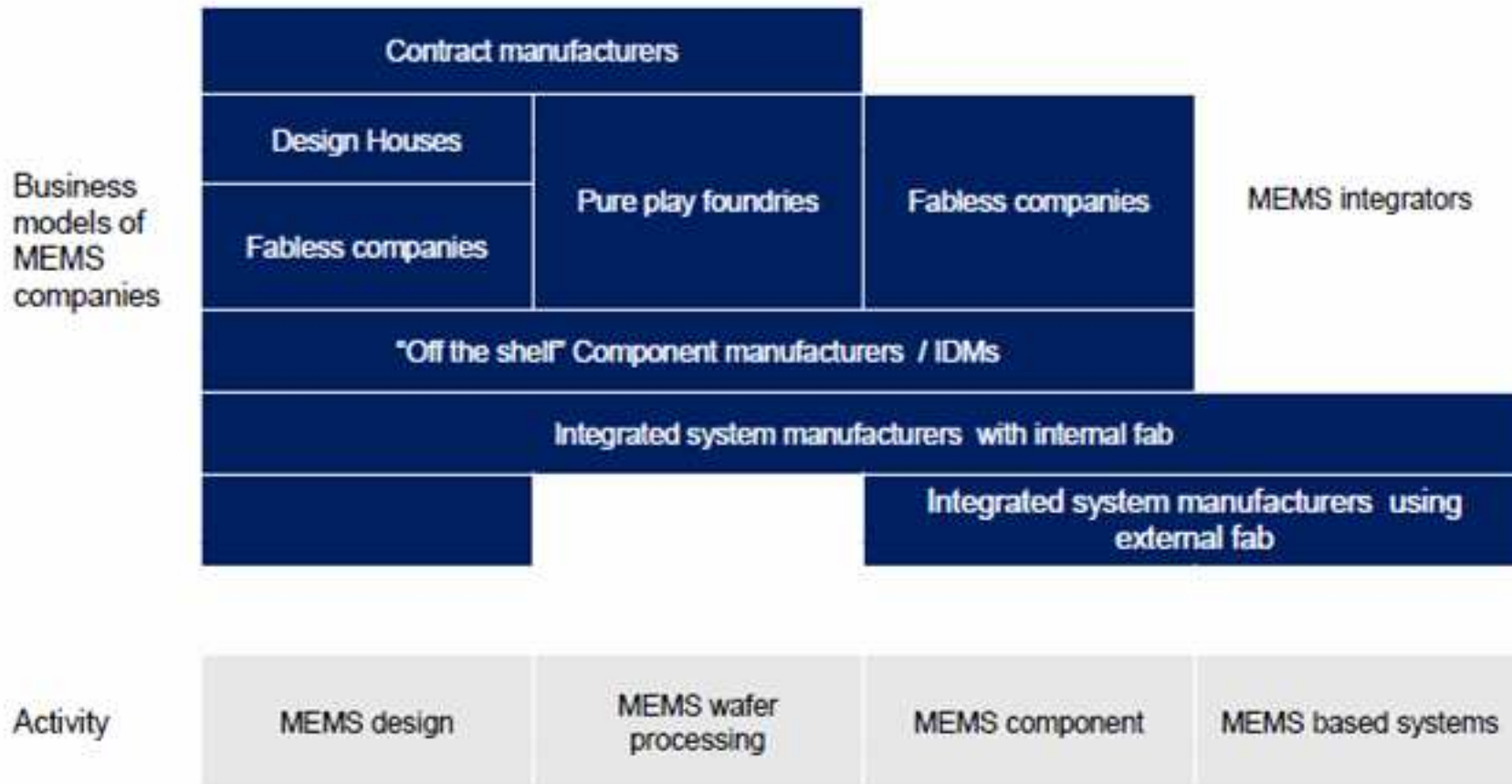
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- *Facts on MEMS Industry*
- ***Volume Production in MEMS Foundry***
- *On Expediting Prototype to Market*

One product, one process, one package

- Different optimum processes for different products remain the norm
- So far, No “standardized” MEMS processes is widely available. Lack of design kit / design environment.
- **Experience is still the prevailing factor!**

Gradually Matured Business Model



Source: Yole report, Sep 2009

→ MEMS foundry business has matured and APM is a good example of this

APM as a foundry example

✓ A pure play MEMS foundry supplier

- *largest in Taiwan, top 10 in worldwide companies providing MEMS foundry service*

✓ Established: Aug. 2001

- *Transferred from a CMOS fab*
- *Night-Year Experiences in MEMS Volume Production*

✓ Employee: ~ 300

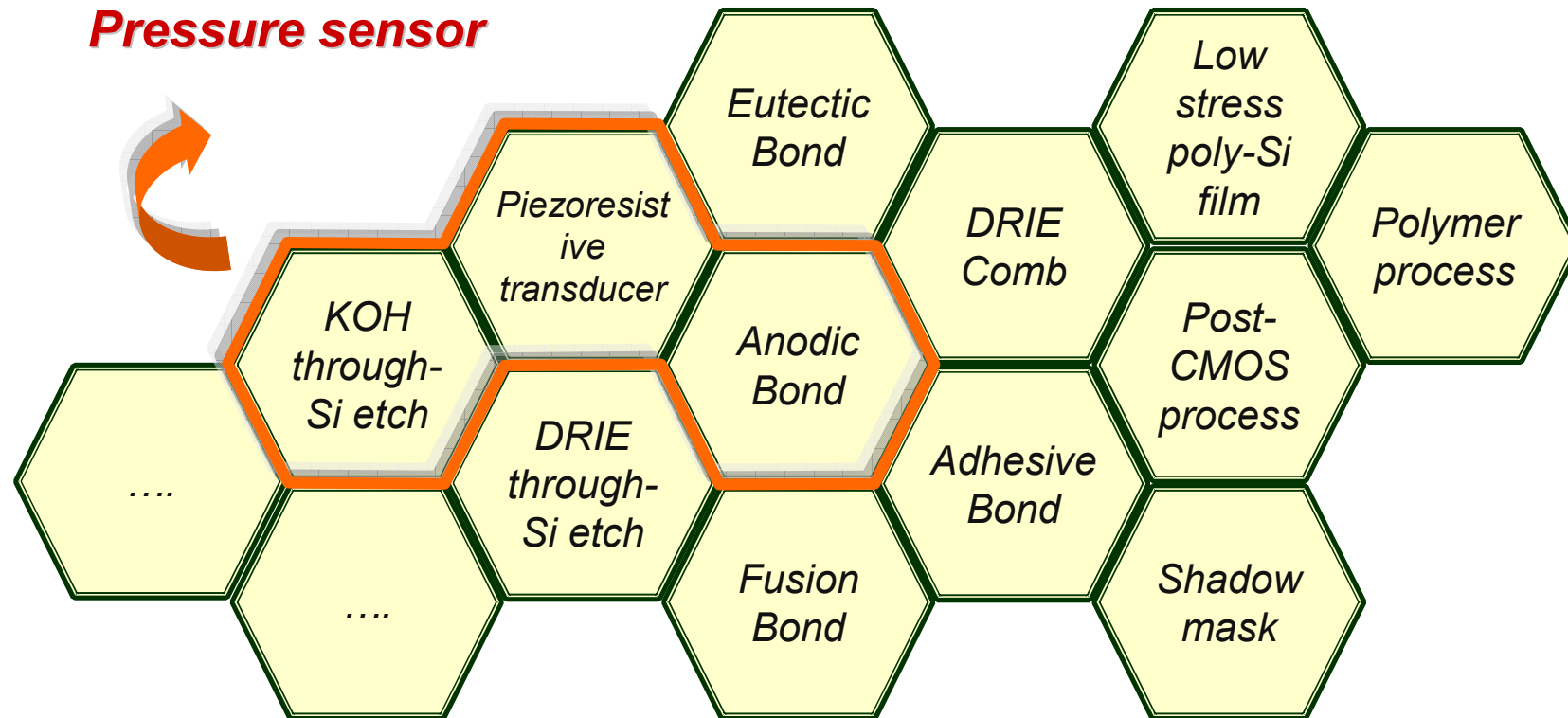
- *MEMS expertise with IC manufacturing discipline*

✓ Production Capability

- *12,000 wafers (6") per month - based on 10 litho steps per wafer*



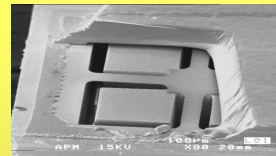
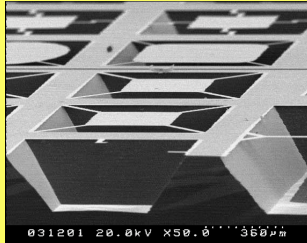
Time-to-Market



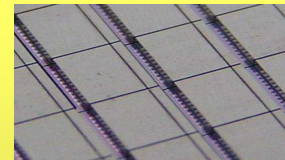
- Advanced process modules as **Building Blocks** to form
- Our standard **Platform** &
 - Customized process flow
- to achieve *fast prototyping & fast production transfer*

APM Core Technologies

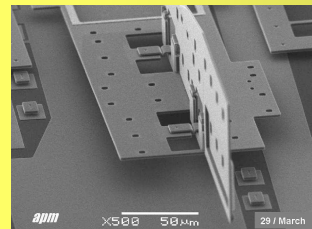
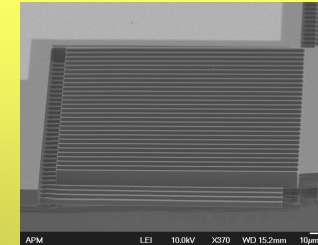
Low stress thin-film module



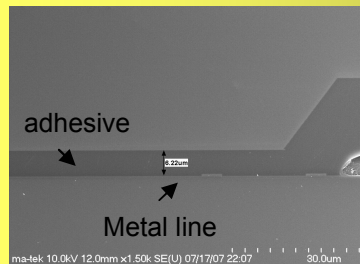
Waferscale encapsulation module



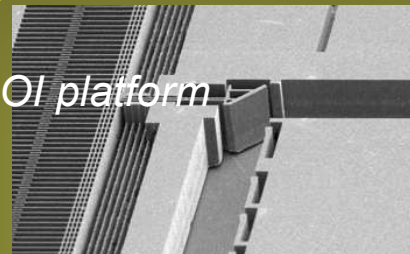
Comb structure DRIE Module



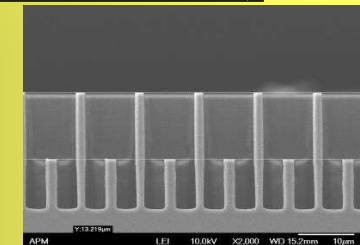
Bonding Module



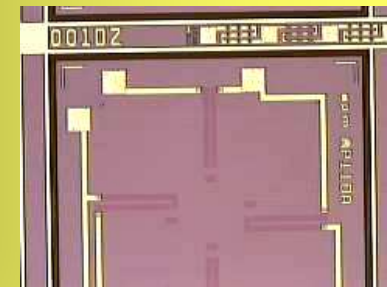
SOI platform



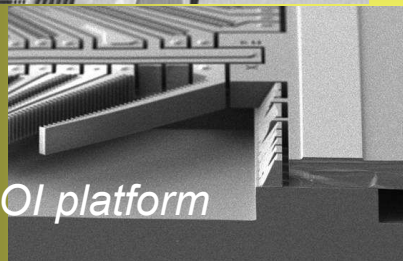
Through wafer suspension platform



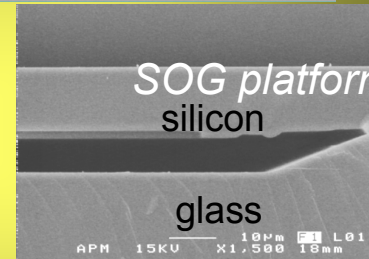
PRT Module



C-SOI platform



SOG platform
silicon

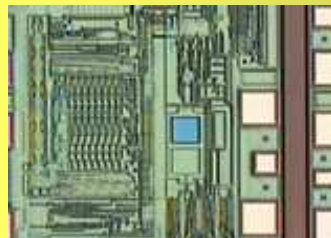
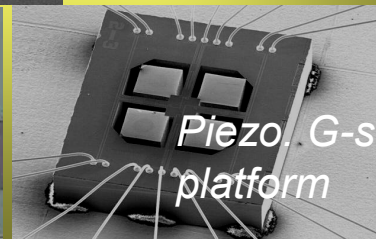


glass

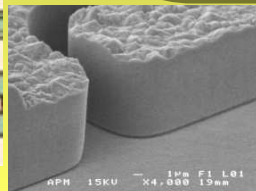
Piezo. Pres.-sensor
platform



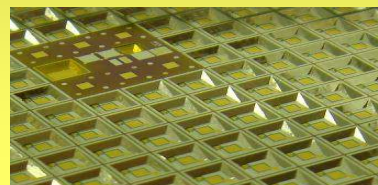
Piezo. G-sensor
platform



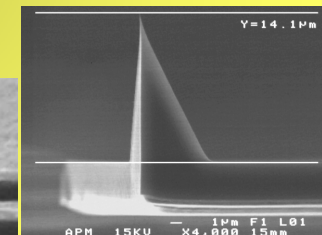
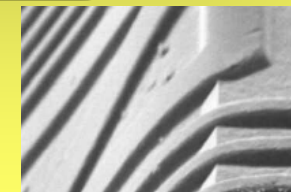
CMOS post processing module



etch-through Module

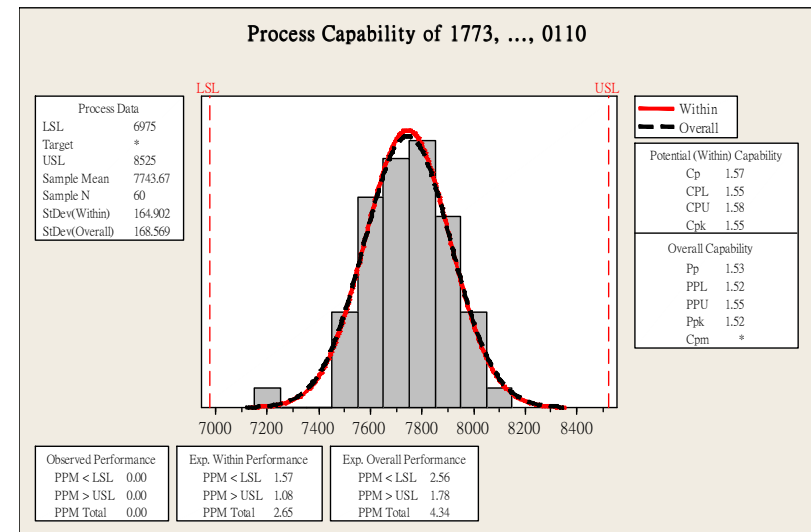


Special process technologies



Difference between running 10 and 100 pcs

- ***On engineer-handling***
- ***On Manuel and Automation***
- ***On lot-to-lot variation***
- ***On capacity expansion***
- ***On New issue***
- ***On Mistake-Proofing***
- ***On Material management***
- ***...***
- ***Variance control, Quality systems, supply chain, and throughput become the major areas***



From prototype to Mass production at APM

Stage	sub stage	wafer classification / charge
Pre-product ion	Pre-transfer	NA
	PV run	EC / engineering wafer price
	Pilot run	EC / engineering wafer price
Mass-product ion	Transfer	NA
	Risk run	PC / production wafer price (lower yield target)
	Production run	PC / production wafer price

Stage	sub stage	wafer classification / charge
Preparation	Planning	run card
	Preparing	NA
	Kick off	NA
Prototype	Short loop / DOE run	run card / NRE
	Trial run	EP / NRE
	DV run	EC / NRE or engineering wafer price

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Lesson learned from the failed case

- *Had a high cash burn rate and ran out of funding*
- *Ignored the importance of packaging/assembly*
- *Not cost competitive at cost sensitive product*
- *Targeted an inappropriate product position (not customer driven)*
- *Targeted an inappropriate market position (market research)*
- *Long verification time / miss the right time to market*
- *Product not well IP protected*
- *...*

Design for Manufacturability

- *Be sure device's critical dimensions are treated by well controlled process*
- *Prevent pushing the design parameter to equipment limit*
- *Understand the process variations and desensitize it through design parameters*
- *Use statistical methods with simulation data to dig out sensitive and insensitive parameters to your product performance*
- *Set test keys for monitoring process condition and measuring the material properties*
- *...*

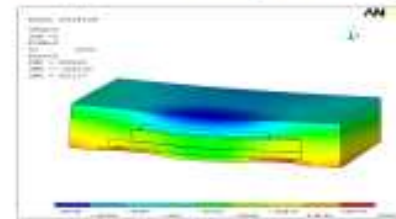
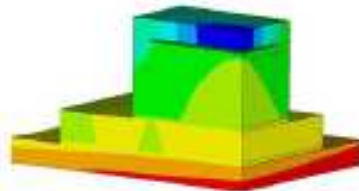
Choose the lowest cost at the beginning

- *Target at right wafer size*
- *Use as many as standard starting material*
- *Prevent complex logistic and multiple IQC/OQC process*
- *Correctly exploit expensive material if it's worthwhile*
- *Prevent too fancy process... simple is elegant*
- *...*

Consider P&T & Reliability at beginning

- *P&T may cost you a lot and can also save you a lot...*

→ Controlling the influence of mechanical stress of package



→ Testing of physical parameters



Source: Bosch

- *MEMS reliability can not be told along, in the beginning, but need to do the best guess through simulation*

To leverage foundry's benefit

- *Select supplier and foundry with proven records*
- *Leverage the well-characterized process modules offered by foundries*
- *Leverage foundries' innovative solutions and bargain power to reduce the cost of the manufactured parts*
- *Fast response to foundry to form a rapid close-loop development*
- *However, it may not be a good idea to develop “just concept” in foundry*

Thanks for your attention!

A nighttime photograph of the Taipei 101 skyscraper, illuminated with green and purple lights, standing prominently against a dark blue sky with scattered clouds. The city lights of Taipei are visible in the background.

Asia Pacific Microsystems, Inc
No. 2, R&D Rd. 6, Science-Based Industrial Park,
Hsinchu, Taiwan, R.O.C.
Tel: +886-3-6661188 ;
<http://www.apmsinc.com>

Vision

A Leader in Microsystems

Mission

*We Provide Microtechnologies
to Enhance
Customer's Competitiveness*

隨裕而安

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