

RF-MEMS:

From Technology Push to Market Pull?

Microwave & RF 2013 – Conférence RF MEMS

10 Avril 2013



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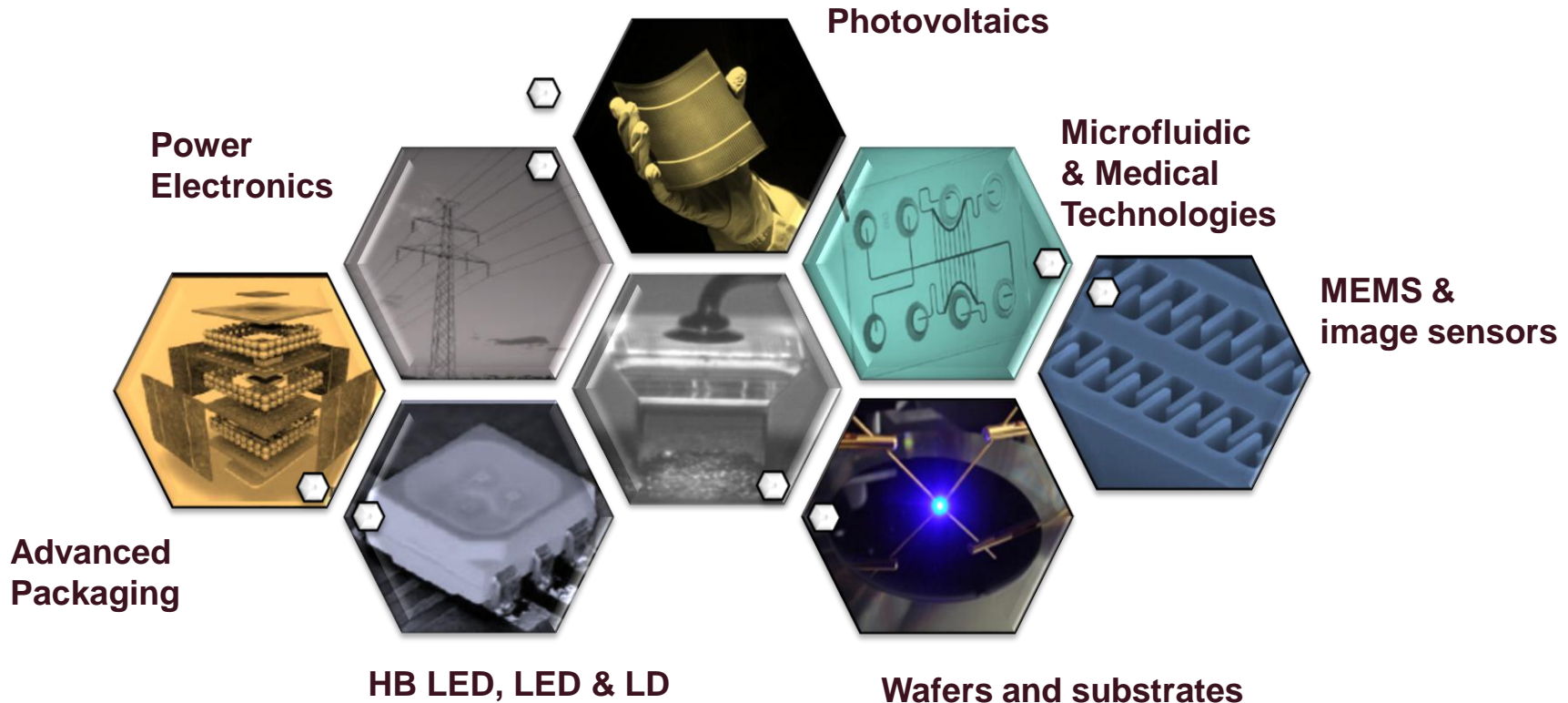
Web: <http://www.yole.fr>

Outline

- **Presentation of Yole Développement**
- **Status of MEMS industry in 2013**
- **The boom of RF-MEMS for cell phone tuning**
- **High-added value application segments**

Fields of Research Activity

Founded in 1998, Yole Développement is a global market, technology and strategy consulting company involved in :



Our research is performed by in-house personnel conducting open-ended discussions based on interviews.

- ▶ 32 full time analysts with technical and marketing degrees
- ▶ Primary research including over 3,500 interviews per year

Yole Développement Services

1. Strategy & Technology Consulting Services

- Market research and marketing analysis
- Strategy analysis
- Technology evaluation
- Reverse costing
- Financial services with Yole Finance

2. Publication of Market & Technology Reports

- >30 reports per year

3. Custom Workshops

- Get data and information on any of Yole's expertise: MEMS, Compound Semiconductors, Advanced Packaging, Photovoltaic ...

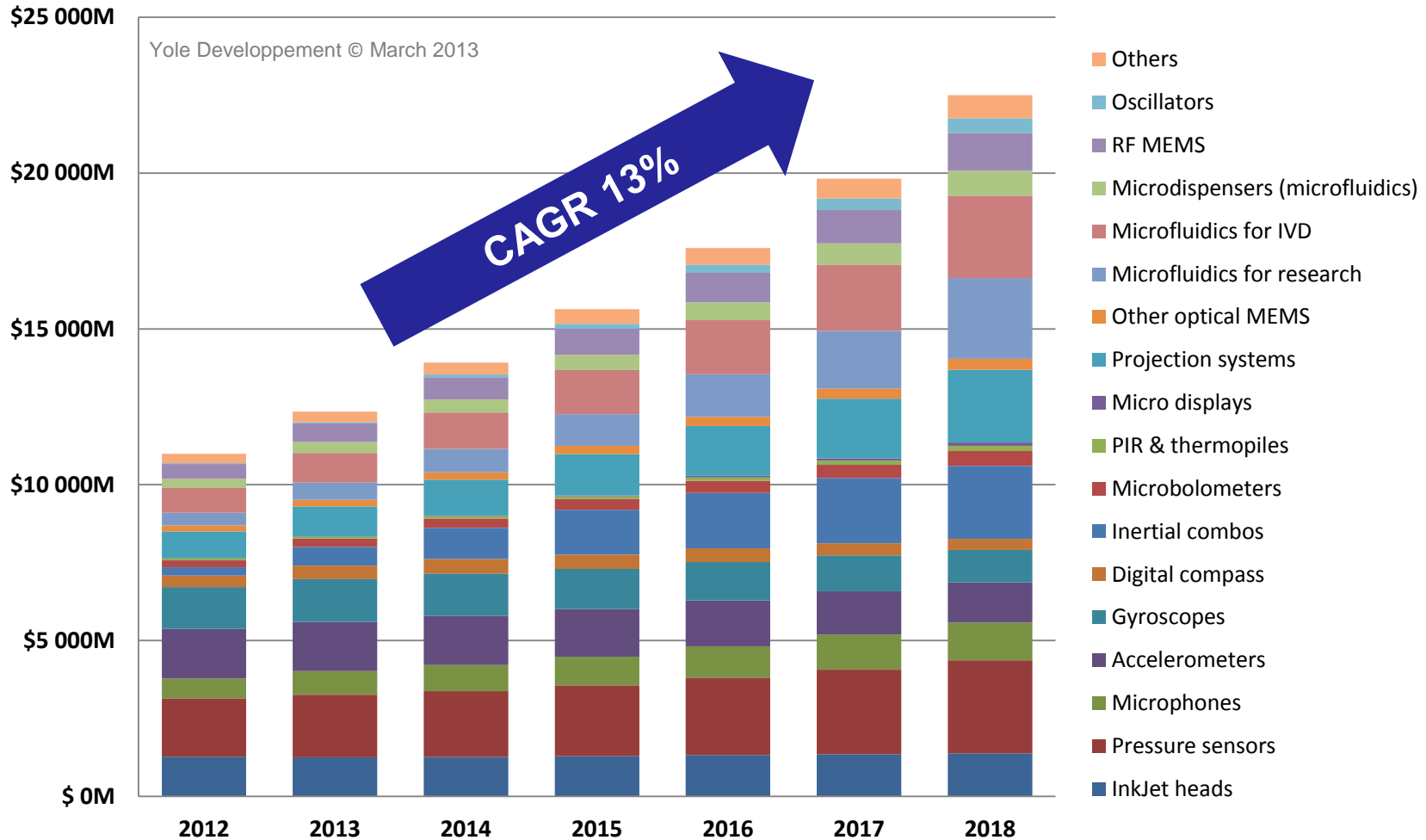
4. Yole Media & Communication Support

- Micronews magazine and website
- Technology magazines: MEMS Trends...

Continued Strong Growth

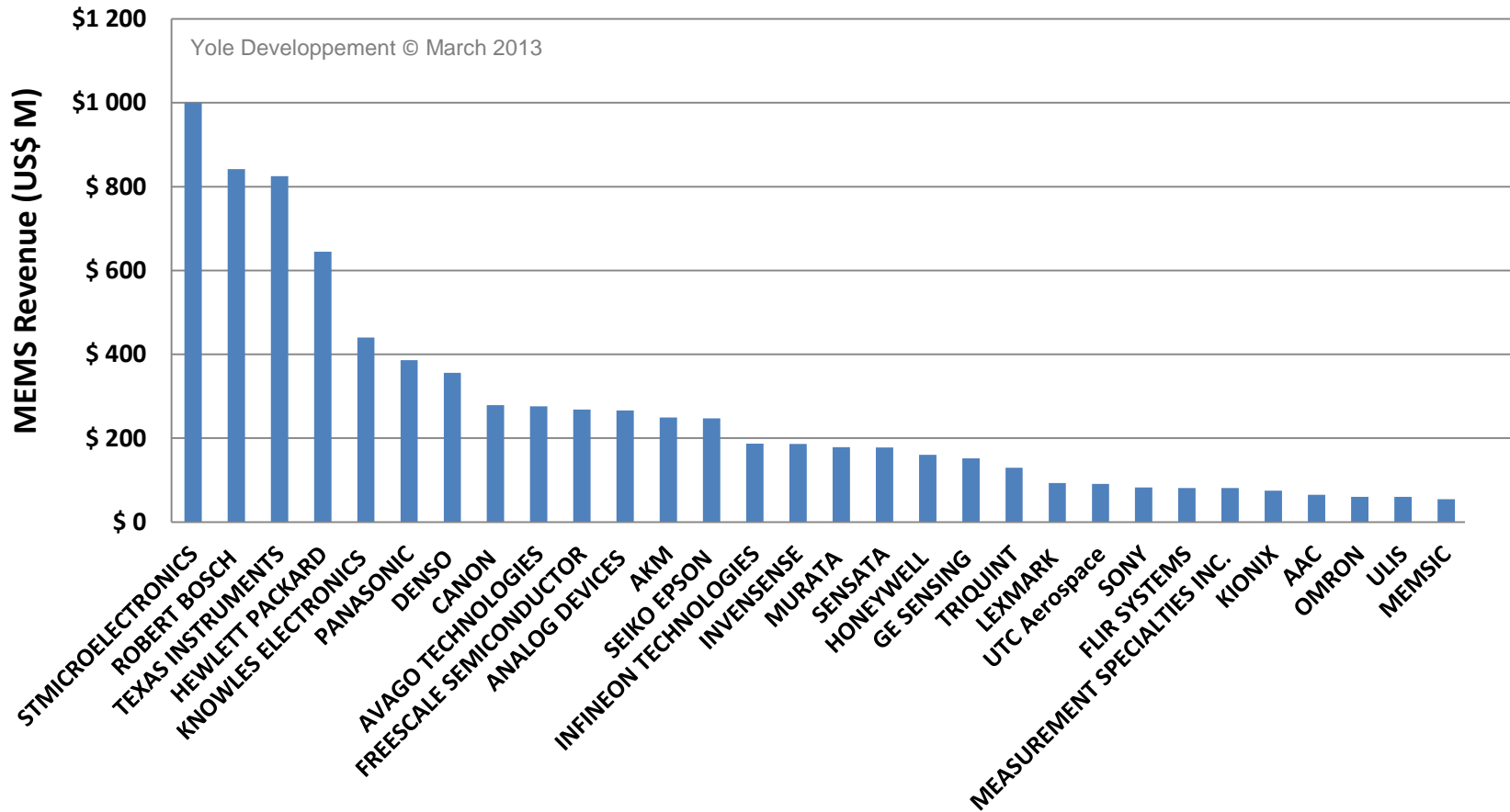
2012-2018 Forecast (in US\$M)

MEMS market forecast 2012-2018 value (in M\$)



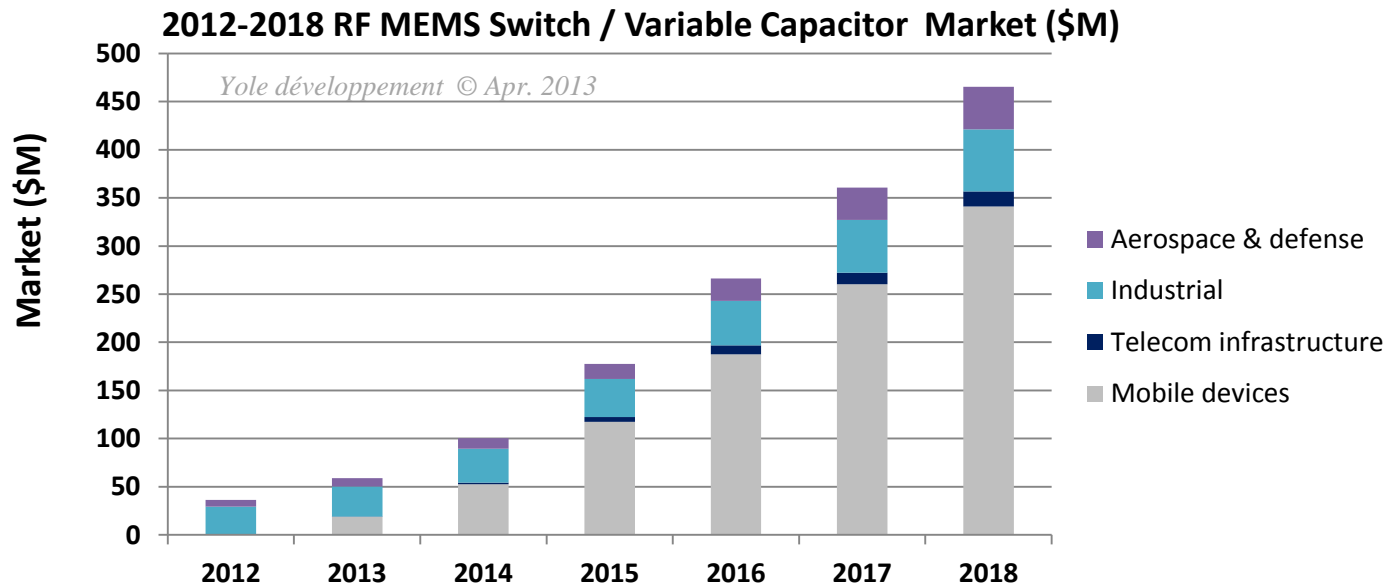
2012 MEMS players ranking Top 30

TOP 30 MEMS Players Ranking 2012



Global RF-MEMS market update

- **Moderate market opportunities in ATE market**
 - RF MEMS used in niche applications, not compete with the mainstream part (solid state switches). This market is conservative
 - Offering becomes broader
 - Trend is to handle higher frequencies
- **Switches for aerospace & defense are already in production, but with limited volume**
- **Mobile phone market started**
 - Strong demand for tuner devices, but strong competition from alternative technologies
 - Yole has revised upwards his forecast for MEMS in ASM with >100M dies expected in 2016



Applications for tunable modules in the radio handset

- A tunable module is built from:

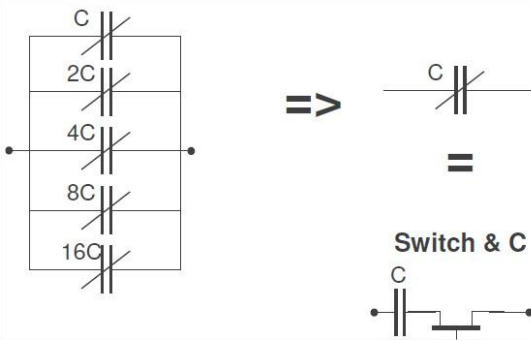
- a switch multiplexer connected to capacitors
- and inductors

Tunable modules will be integrated in three handset locations:

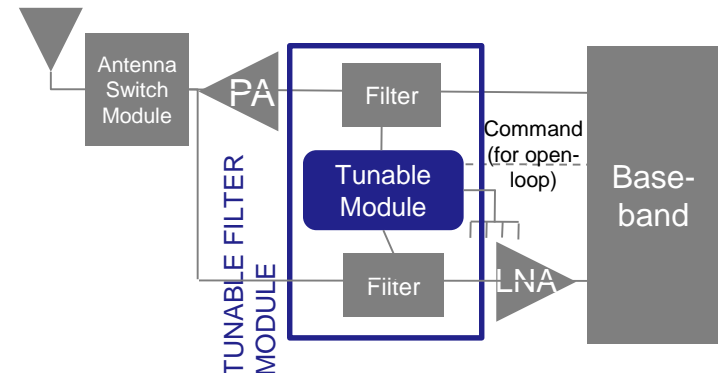
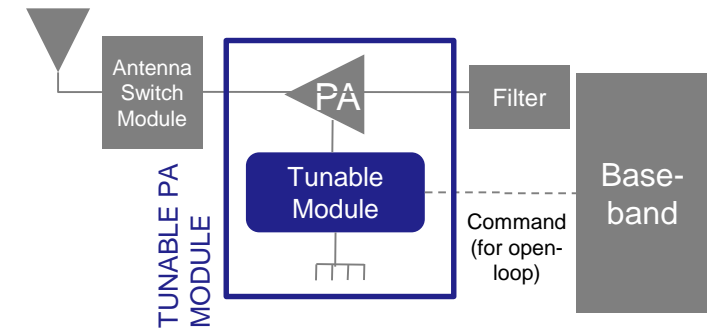
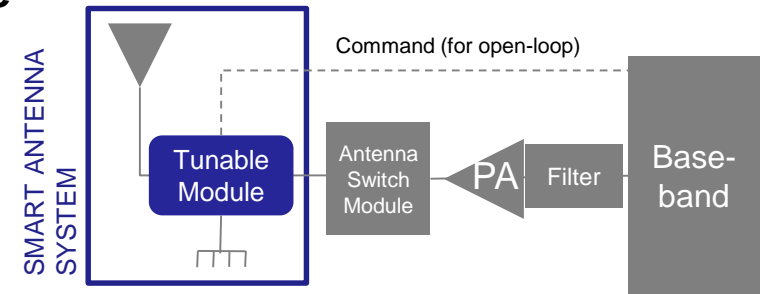
→ **Antenna tuning**

→ **Tunable PA**

→ **Tunable filter / duplexer**



Source Epcos



Drivers for RF tuners

... and MEMS value proposition

Drivers for RF tuners



Increasing number of bands and antennas

LTE

Carrier aggregation

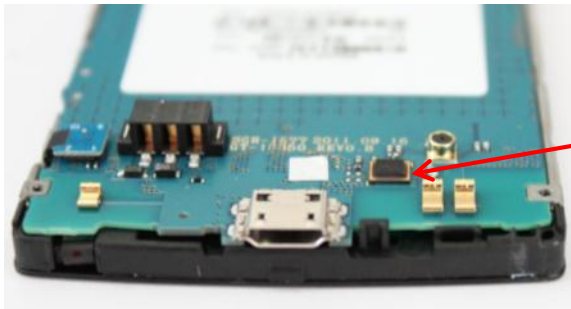
Operators demand for more users per BST + more data per user

Smaller antennas for smaller phones

MEMS value proposition

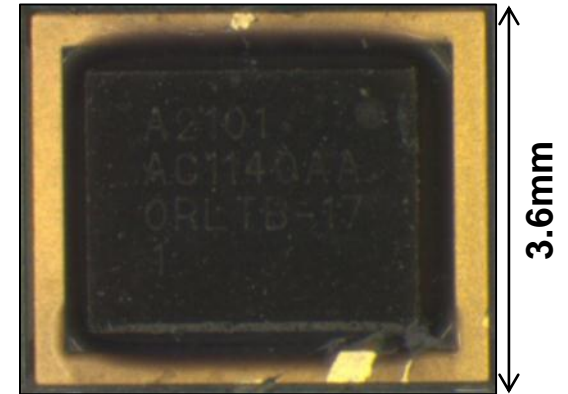
- Very high Q
- Excellent linearity over wide frequency range
- Low loss
- High capacitor range
- Digital control, that can be integrated
- Low power consumption (electrostatic actuation)

Wispry reverse engineering



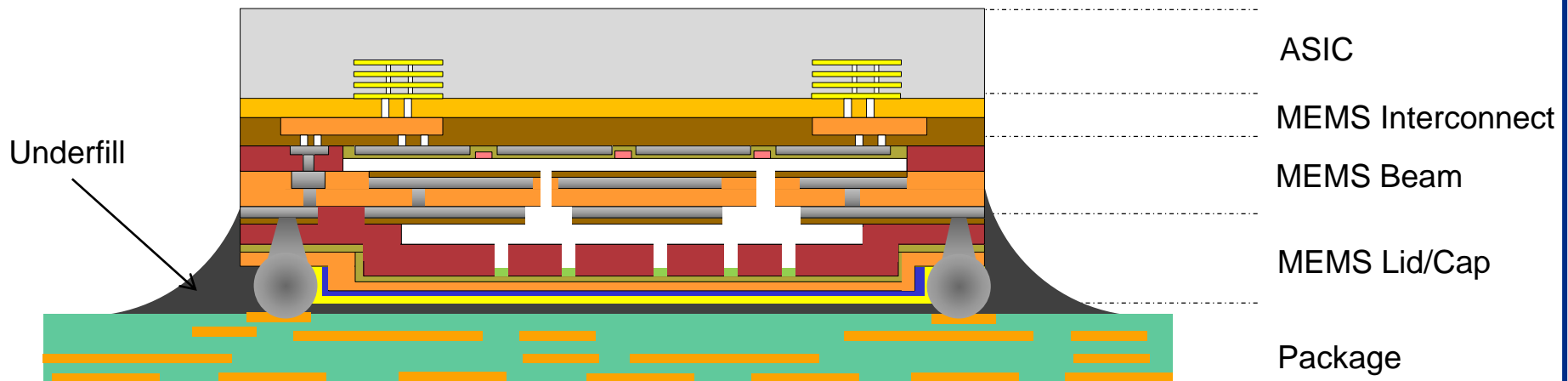
Wispry RF MEMS

Package side view



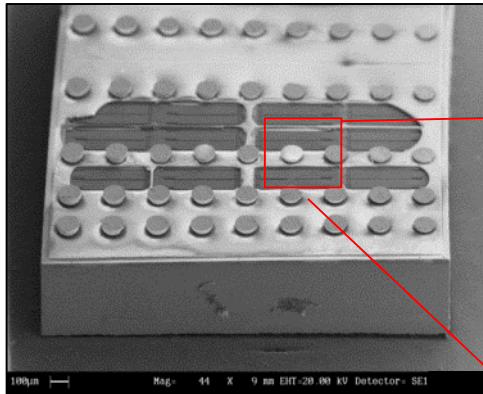
Package Top view

4.2mm

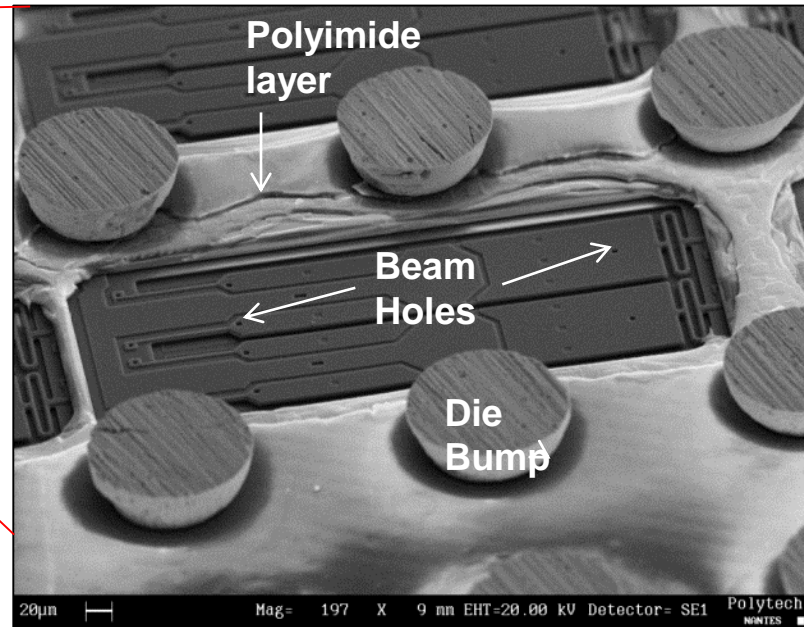


Wispry reverse engineering

Die – SEM View



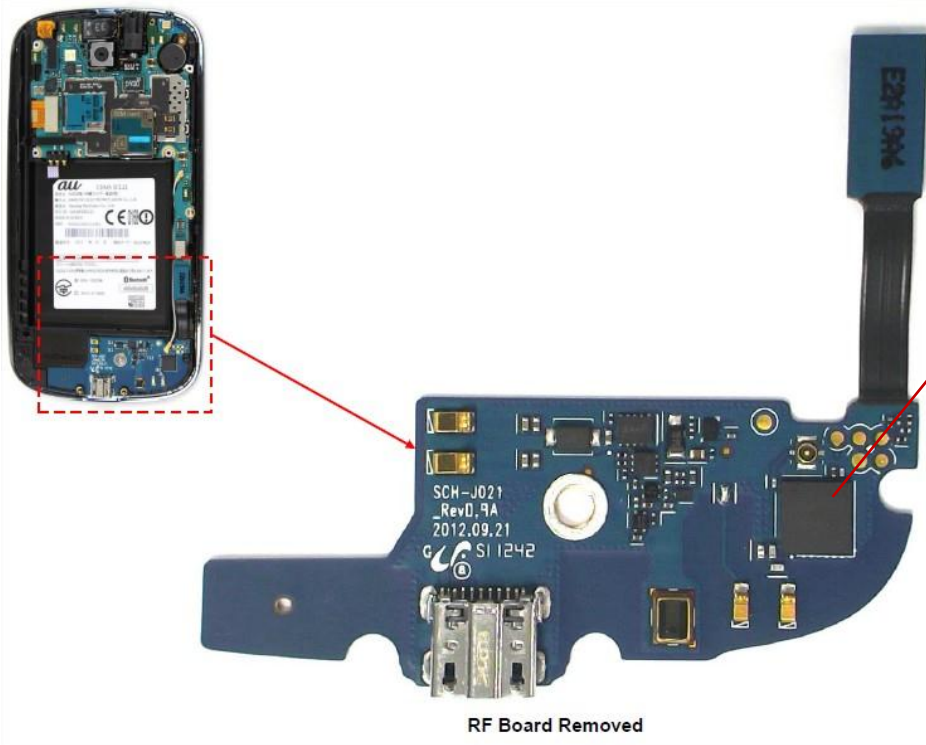
Die SEM view



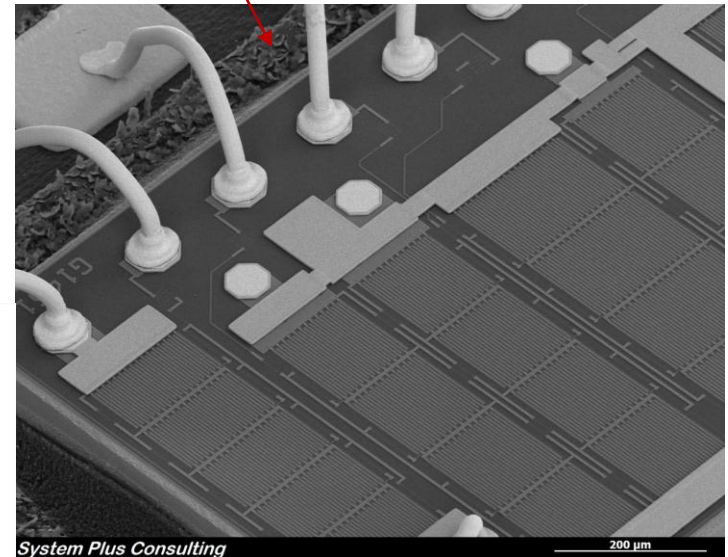
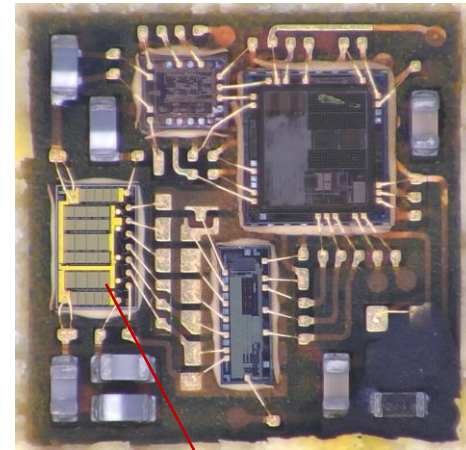
Die SEM view

Proliferation of RF tuners

First Epcos close loop tuner on the market!

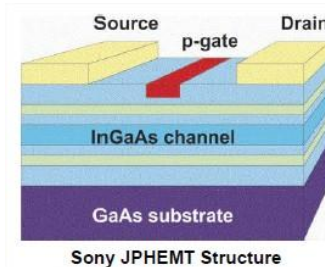


RF Board Removed



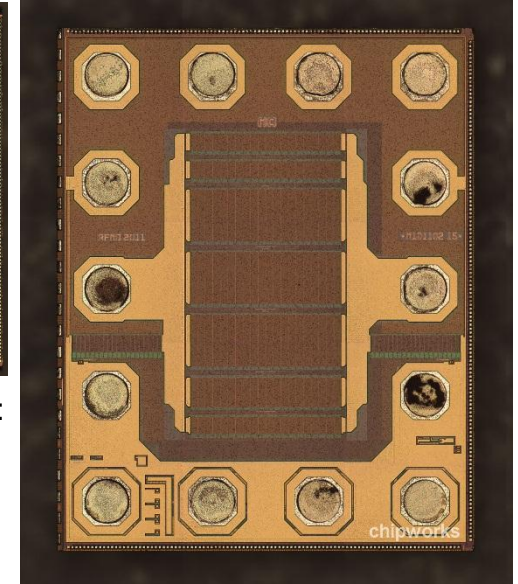
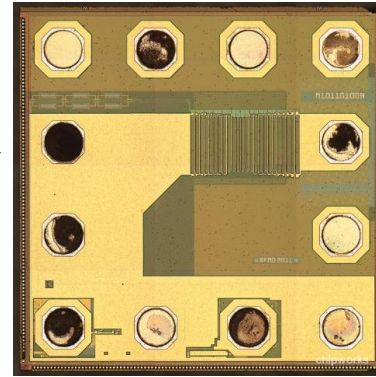
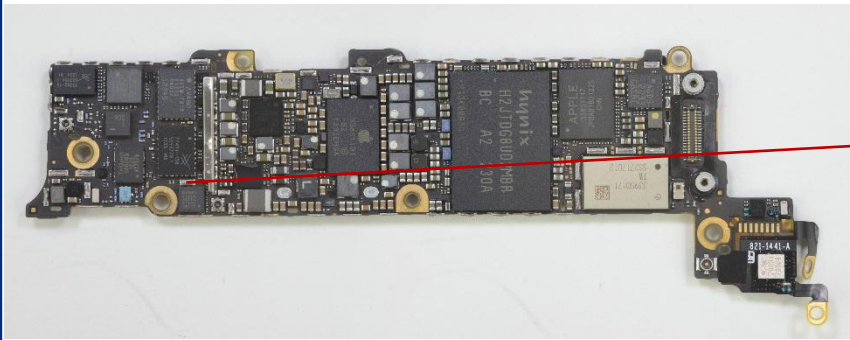
System Plus Consulting

200 μm

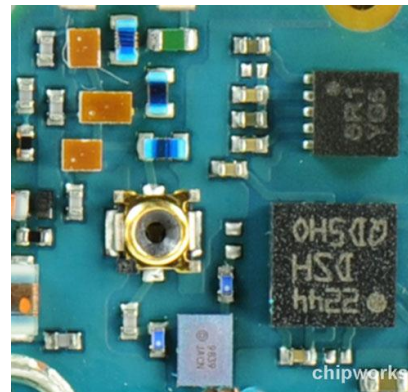
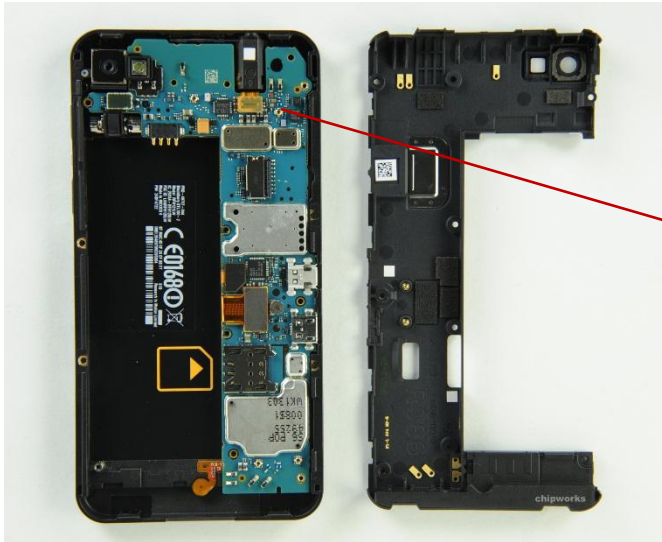


Proliferation of RF tuners

2 antenna tuners in iPhone 5!



RFMD RF1101 and RF1102 tuners for 2 applications in iPhone 5:
→ Diversity antenna for low band LTE
→ Main cellular antenna
(source Chipworks)



In Orange: 3 BST ICs used for impedance matching in BlackBerry Z10!
(source Chipworks)

Cellphone RF tuners for cell phones

Position of MEMS today

Performance
dB improvement
Q factor
Number of capacitors

Epcos
Open loop

Wispry
15mm² → 5mm² today (WLCSP) → 4mm²

Cavendish
WLCSP - 2mm² (only MEMS part)

On Semi, STM, Blackberry

Peregrine

RFMD
Qualcomm...

Price
Size

\$1

75 cents

50 cents

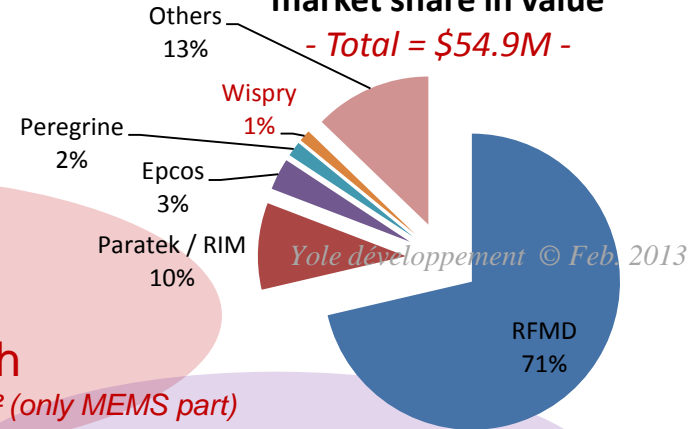
GaAs

MEMS

BST

SOI - SOS

2012 cellphone impedance matching module market share in value



Cellphone RF tuners for cell phones

Tomorrow expectations

Performance
dB improvement
Q factor
Number of capacitors

Epcos
Open loop

- Development of close loop solutions
- Diversification: tunable filters...

Wispry

15mm² → 5mm² today (WLCSP) → 4mm²

- Package and die shrink
- New players

Cavendish

WLCSP - 2mm² (only MEMS part)

- Lower cost product lines (less capacitors)

On Semi, STM, Blackberry

Peregrine

RFMD
Qualcomm...

Price
Size

\$1

75 cents

50 cents

GaAs

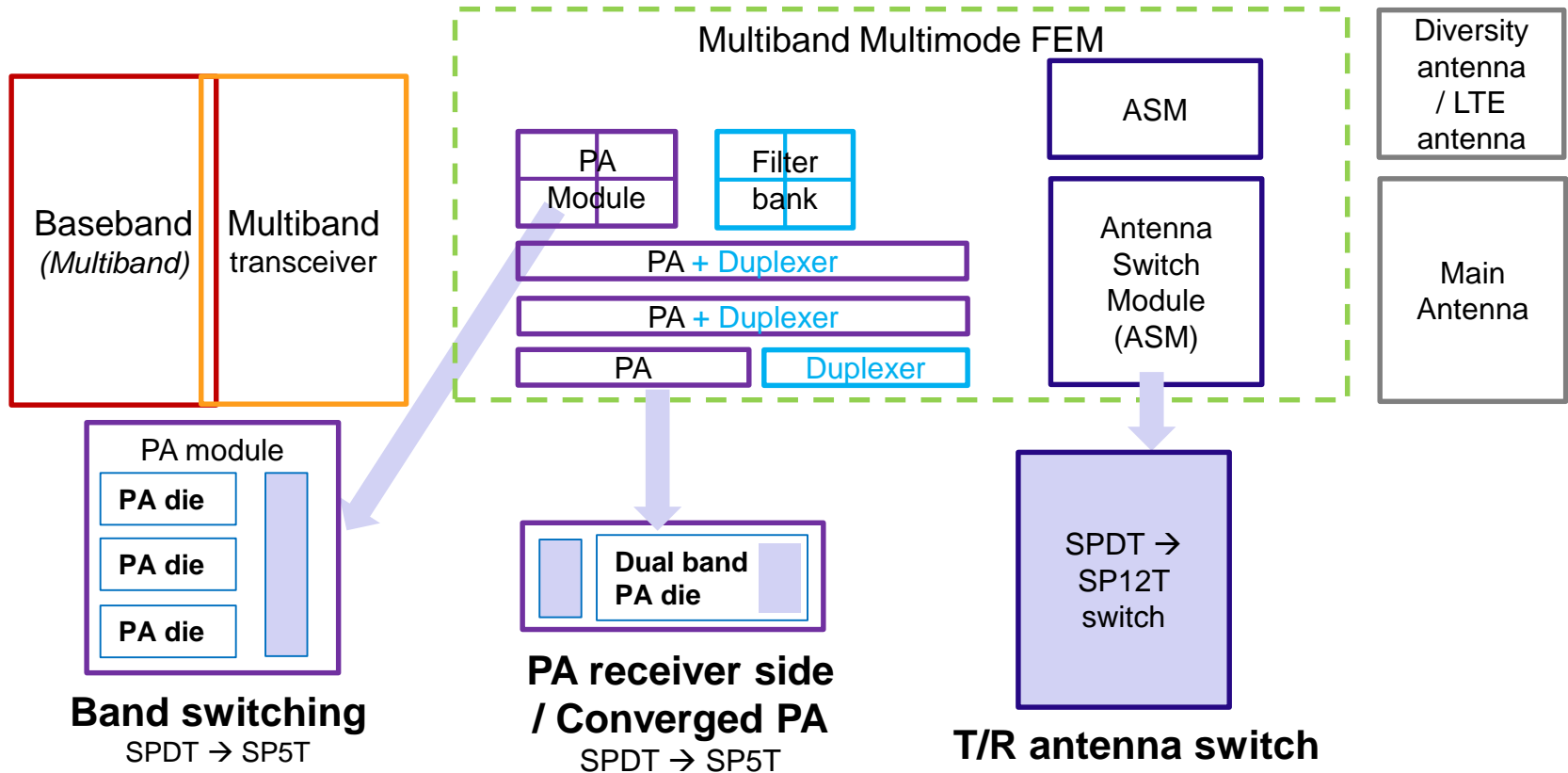
MEMS

BST

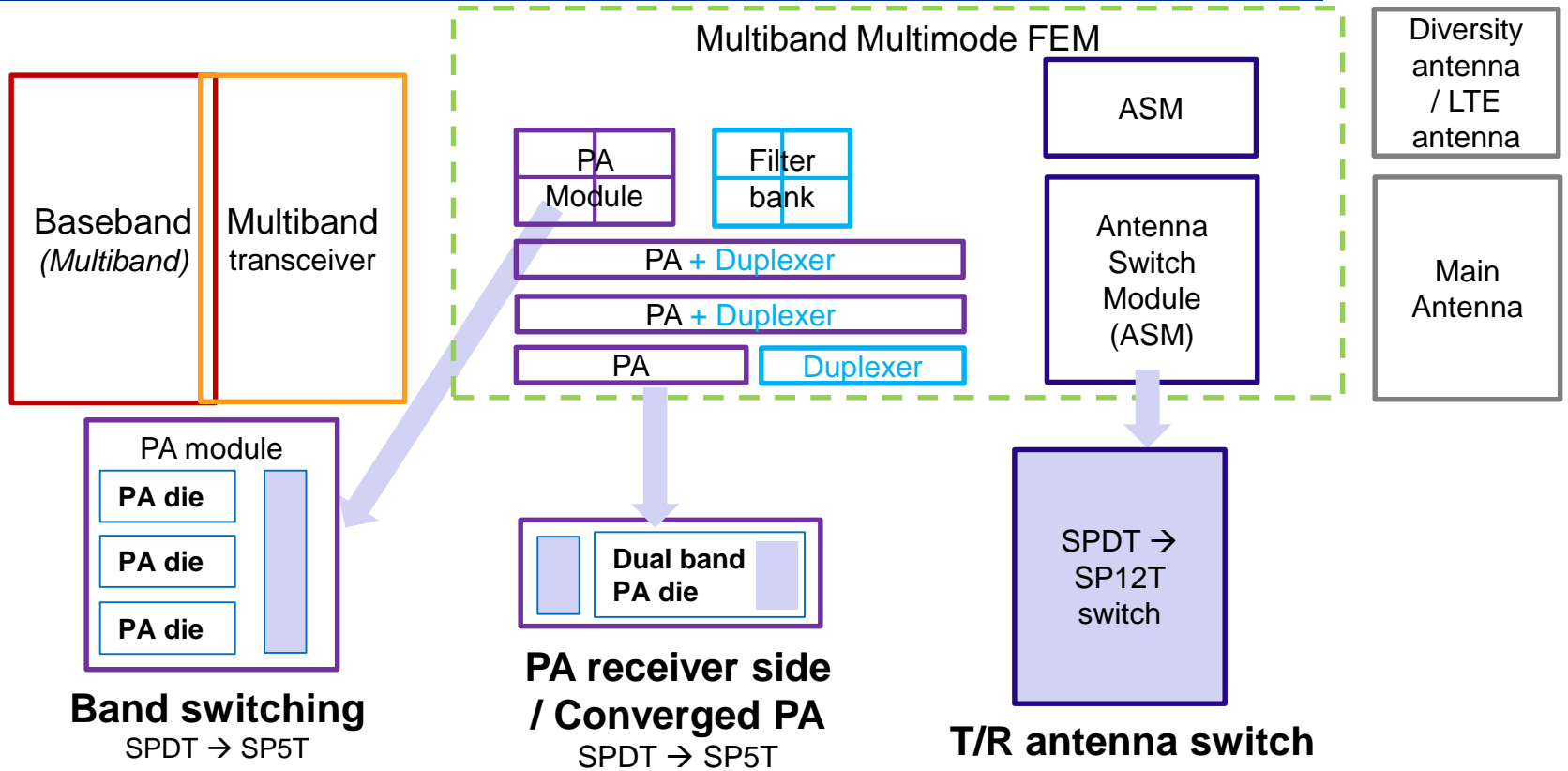
SOI - SOS

RF switches: another MEMS opportunity

➤ Many opportunities for switches:



RF switches: another MEMS opportunity



➤ Different technology candidates:

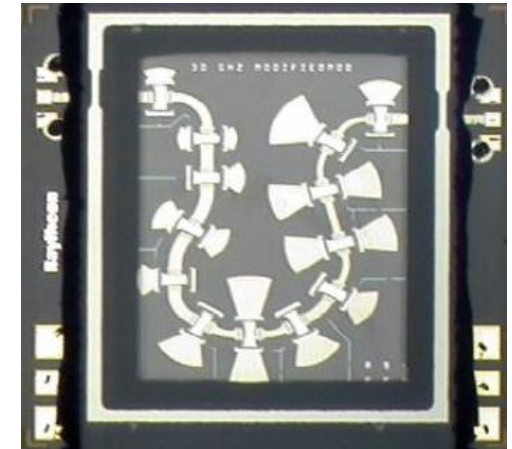
- 1. GaAs substrate
- 2. HR-SOI substrate
- 3. SOS substrate
- 4. CMOS (Infineon)
- 5. MEMS (emerging)



Source DelfMEMS

High added value applications for RF-MEMS switches/varicaps

- The use of MEMS switches in high-end markets depend on 5 key parameters:
 - Configuration: a fonction is requested, not a single switch/varicap
 - Frequency range
 - Switching time
 - Power handling
 - Cycling
- RF MEMS switches/varicaps value proposition:
 - Low loss and high isolation, enabling new architectures
 - Less power consumption (than EM relay)
 - Potential for low cost and high level of integration
 - Can enable a decrease of size / weight of the system



30 GHz MEMS Phase Shifter from Raytheon



High added value applications for RF-MEMS switches / varicaps

RF-MEMS switches / varicaps

Military radars

- Electronically scanned array
- Circulator in TR modules
- Adaptive antennas
- Others: receiver protection devices...



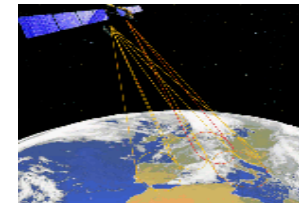
Communication

- Commutation between filters
- Adaptive filters
- TR modules
- Steering antennas



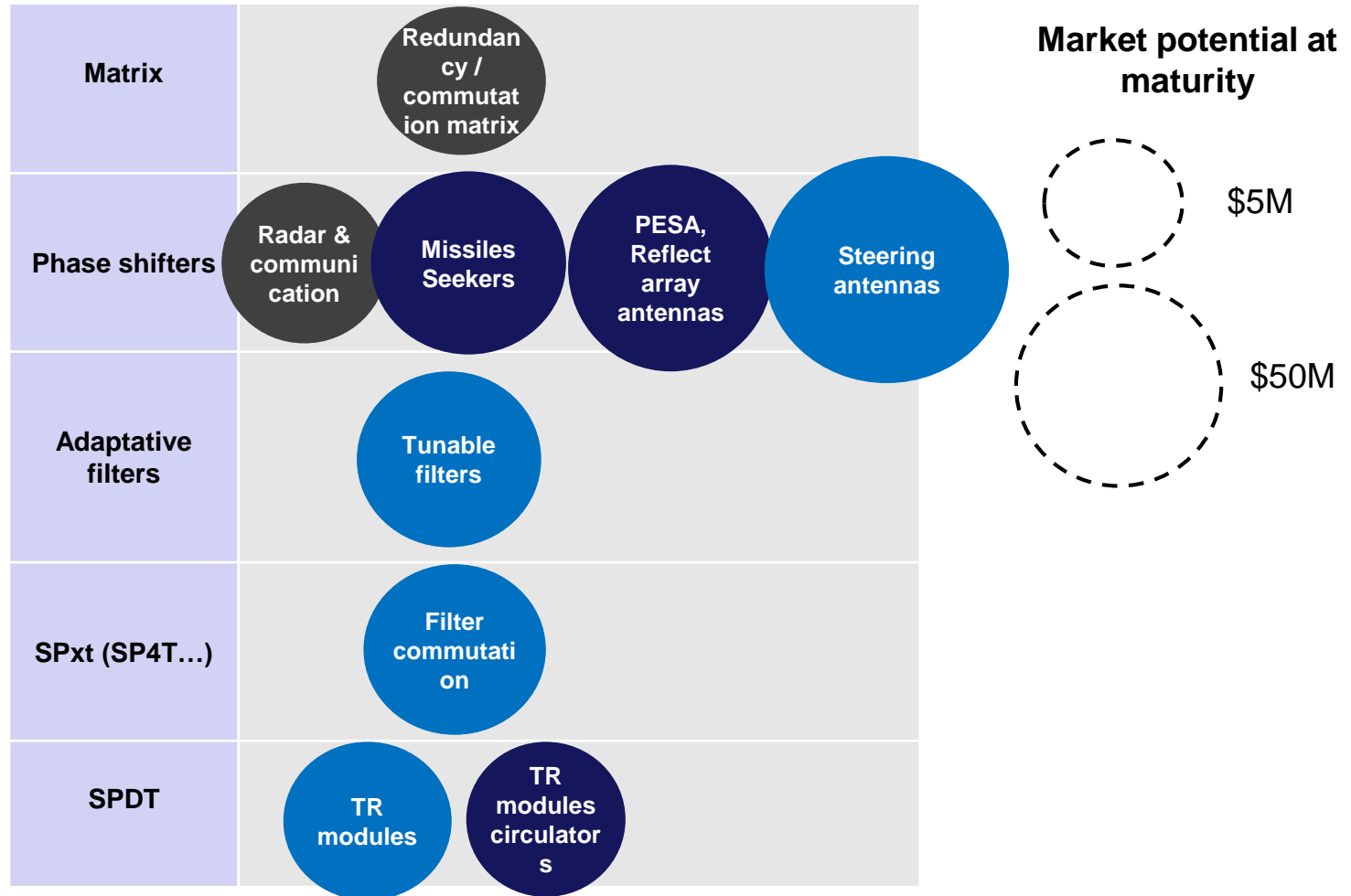
Space

- Redundancy matrix
- Commutation matrix
- Space radars & communication: reflect array antenna, PESA...



High added value application segments

Circuit configurations and market potential



- COMMUNICATION field
- RADARS field
- SPACE field

Recent activity in RF MEMS for aerospace & defense applications

Market trends

- **The market is still not mature**
 - Limited availability of MEMS products
 - Still limited adoption of MEMS technology : MEMS is still a R&D topic
- **Market is still dominated by development contracts**
 - E.g. European projects involving ESA for Space, or on packaging of RF MEMS (with Ommic...)
 - Large integrators such as Thales, Raytheon... are often part of such programs
- **The number of RF MEMS initiatives is still high, and leads to more and more commercial companies**
 - AirMEMS, RFuTech, Proton Microtechnik...
 - Technology evolutions: focus on higher reliability, and lower actuation voltage
 - Many developments focus on product platforms that customers can customize for each application (e.g. Proton Microtechnik)

Summary

- **MEMS industry is big and growing**
- **Strong market pull observed for RF tuners in cell phones**
- **Still techno push for industrial and high-end markets**

Merci pour votre attention!

Questions

For more information:



www.yole.fr



www.i-micronews.com