



International Microelectronics
Assembly and Packaging Society

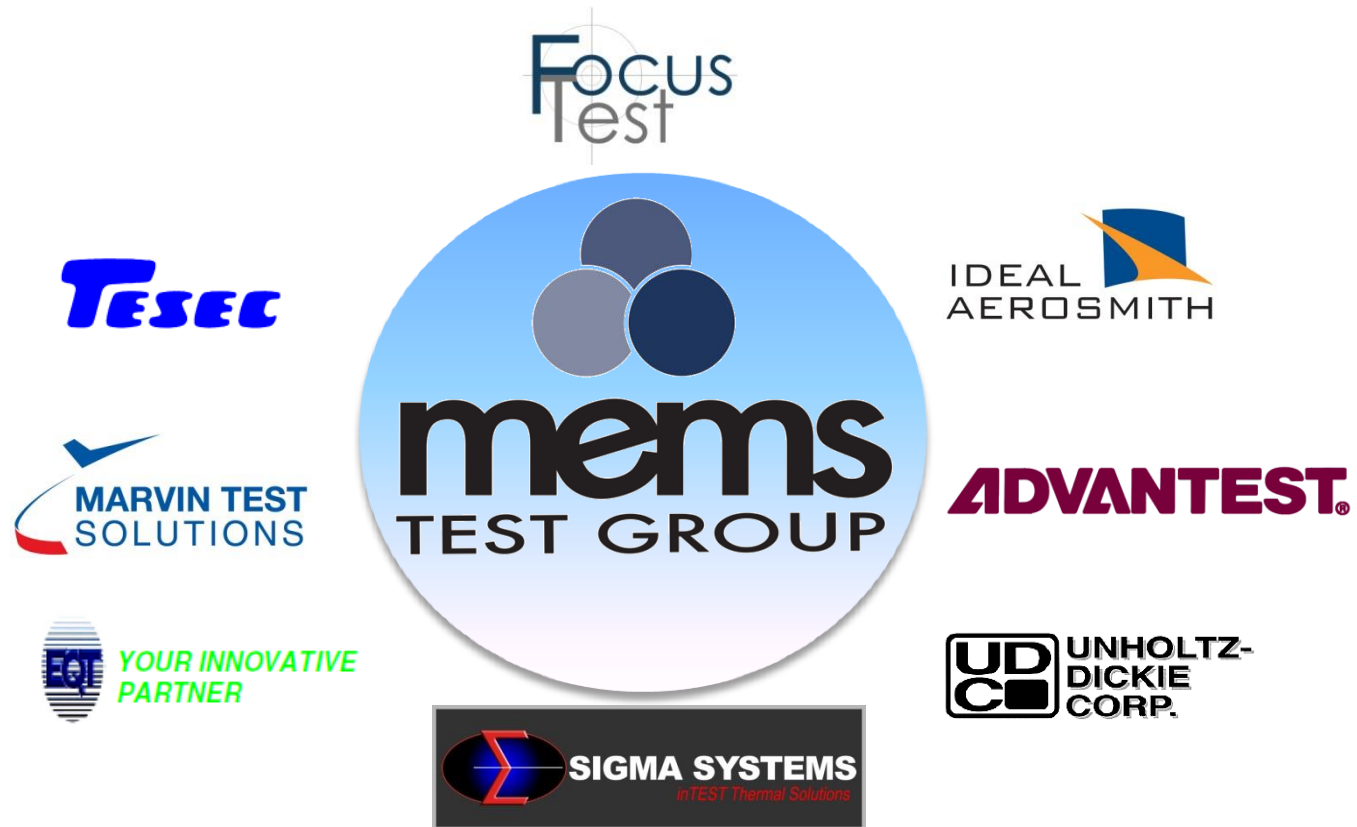
Bringing together the entire microelectronics supply chain™

Session 13

Challenges Testing MEMS Devices

Richard Chrusciel, FocusTest, Inc.

The MEMS Test Group



The MEMS Test Group is an alliance of companies, working together to provide superior technology and the most cost effective turnkey handling and test cells for MEMS semiconductor devices.



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Challenges of Testing MEMS Devices

- General Overview – What is a “MEMS” Device
- What is so Important about MEMS?
- Why is Testing MEMS Different?
- What are some of the Problems?
- What is Needed to Solve the Problems?

Challenges of Testing MEMS Devices

What is a MEMS Device ?

(**M**icro **E**lectronic **M**echanical)

Ink Jets

Microphones

Accelerometer (Hi-G)

Gyroscope

Magnetometer

Accelerometer (Lo-G)

Pressure Sensors

Temp Sensors

RF MEMS

Micro Display

Projection Systems

Optical Sensors

Microfluidics

Oscillators

Inertial “IMU” Combo

E-Compass

Tire Pressure Monitor TPMS

Depth / Altitude

Many, Many more...

Challenges of Testing MEMS Devices

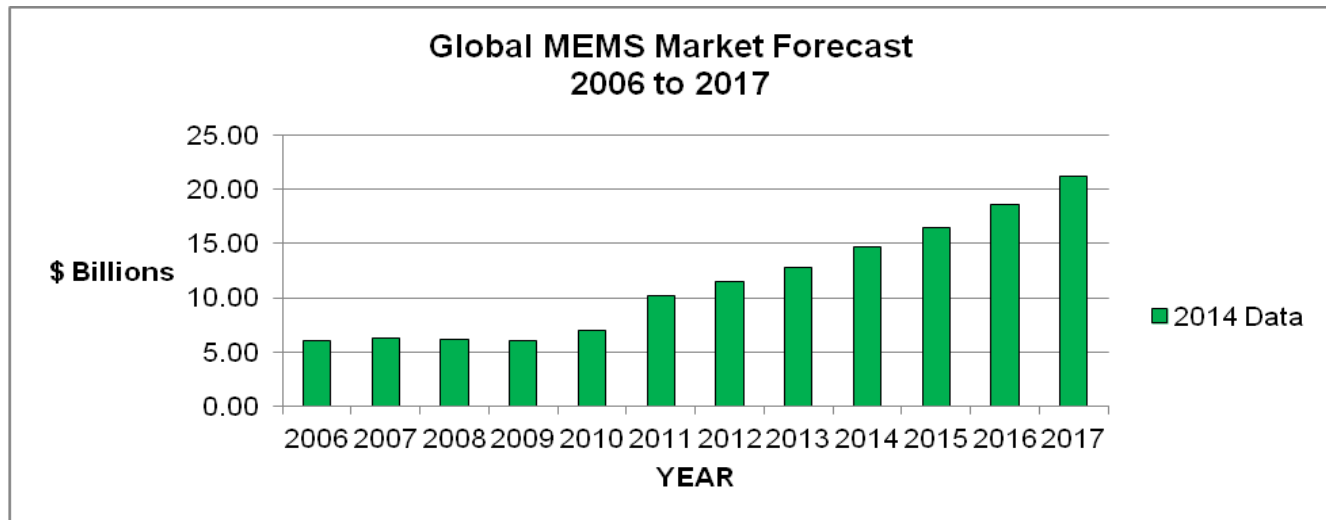
What are the Applications ?



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Challenges of Testing MEMS Devices

How Big is the Market ?



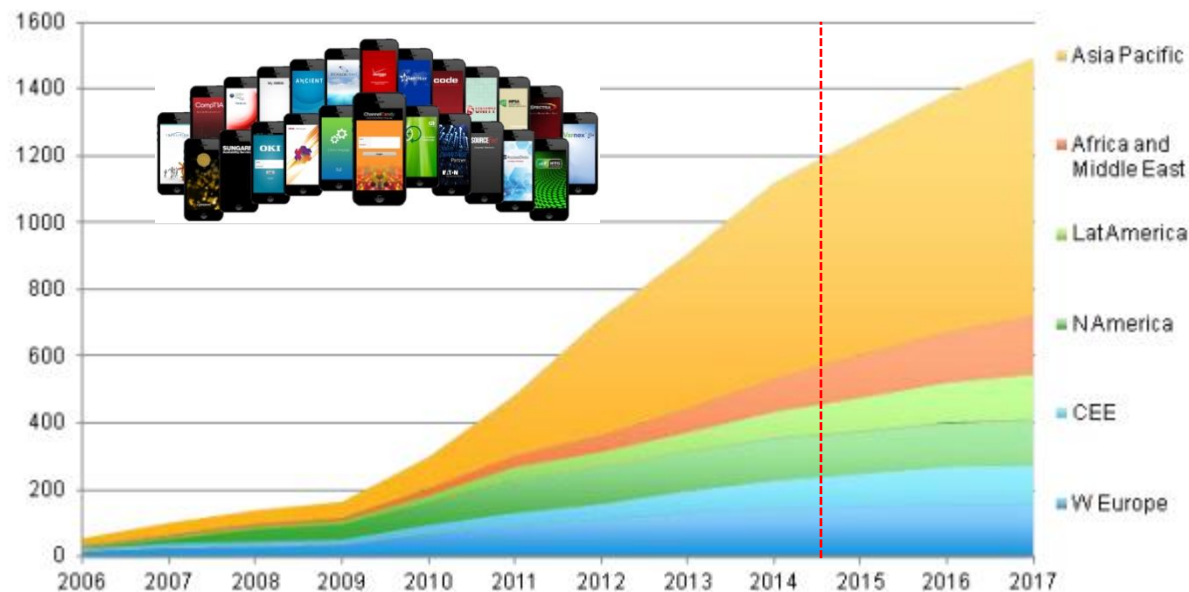
Global MEMS Market is expected to rise to >\$20B by 2017

- Growth rate is +12% (Double the Semiconductor market)

Source: iSupply 2014

Challenges of Testing MEMS Devices

What about MEMS Market Growth ?



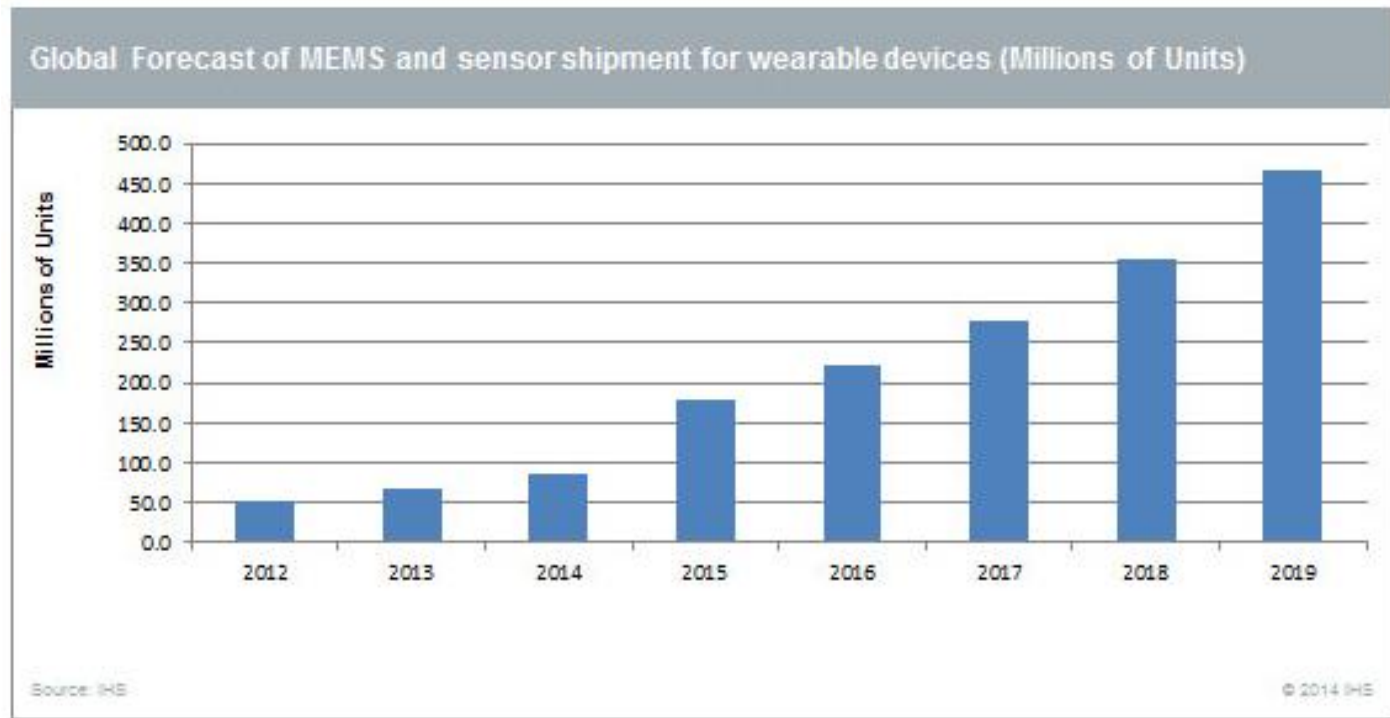
Smartphone Global Market

- ≈1.75 BILLION People Own & Use a Smartphone
- That is 1/4 of the World's Population!
- By 2017 Expanding to 1/3 of the World's Population

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Challenges of Testing MEMS Devices

What about MEMS Market Growth ?

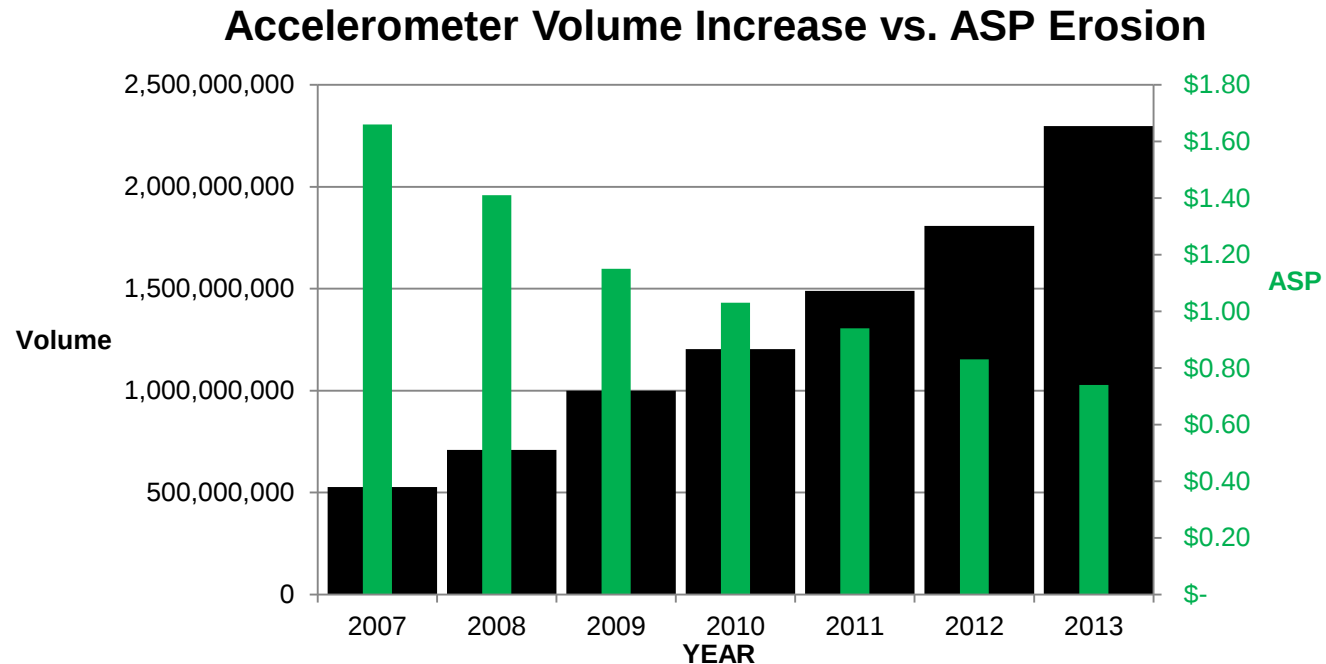


Points of Interest

Source: iSupply 2014

- The Internet of Things is Already Here!
- Wearable Devices: The Next Big Thing

Challenges of Testing MEMS Devices



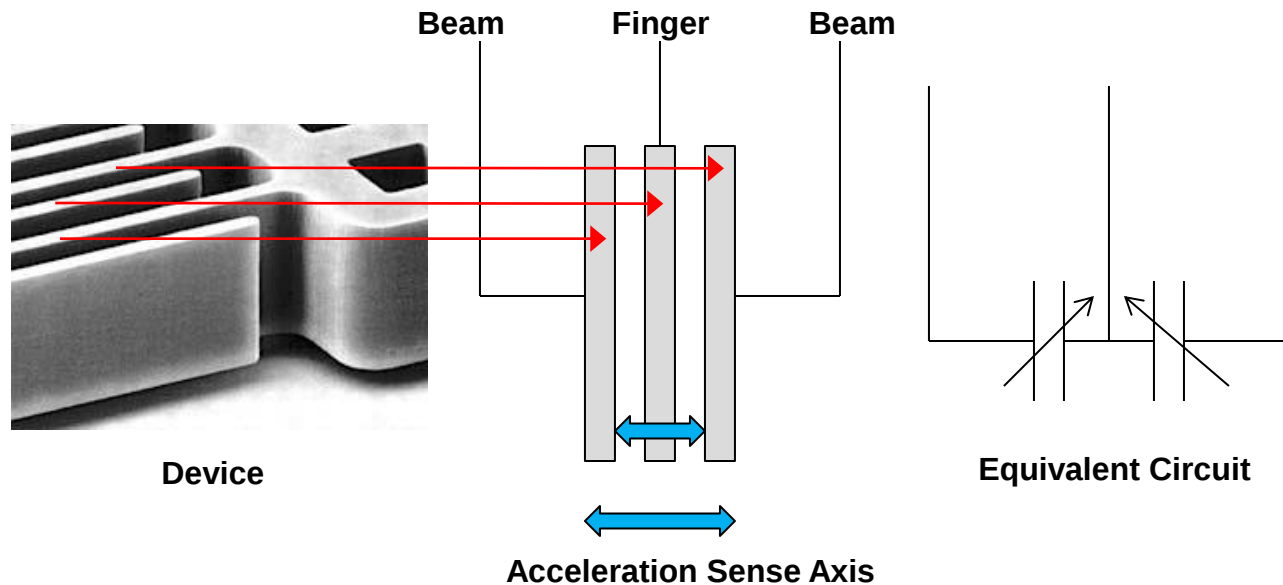
Point of Interest...

- With ASP on the decline while Volumes are on the increase Cost of Ownership and Cost of Test (COT) are very significant issues for MEMS manufacturers.

Challenges of Testing MEMS Devices

How Does It Work ?

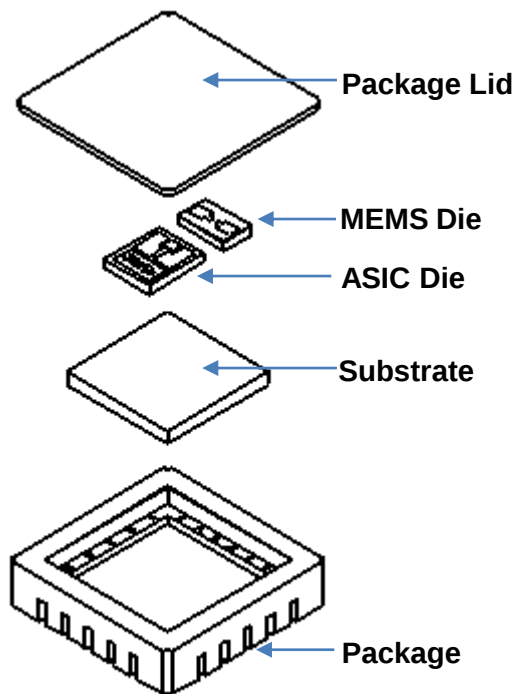
Accelerometer Example:



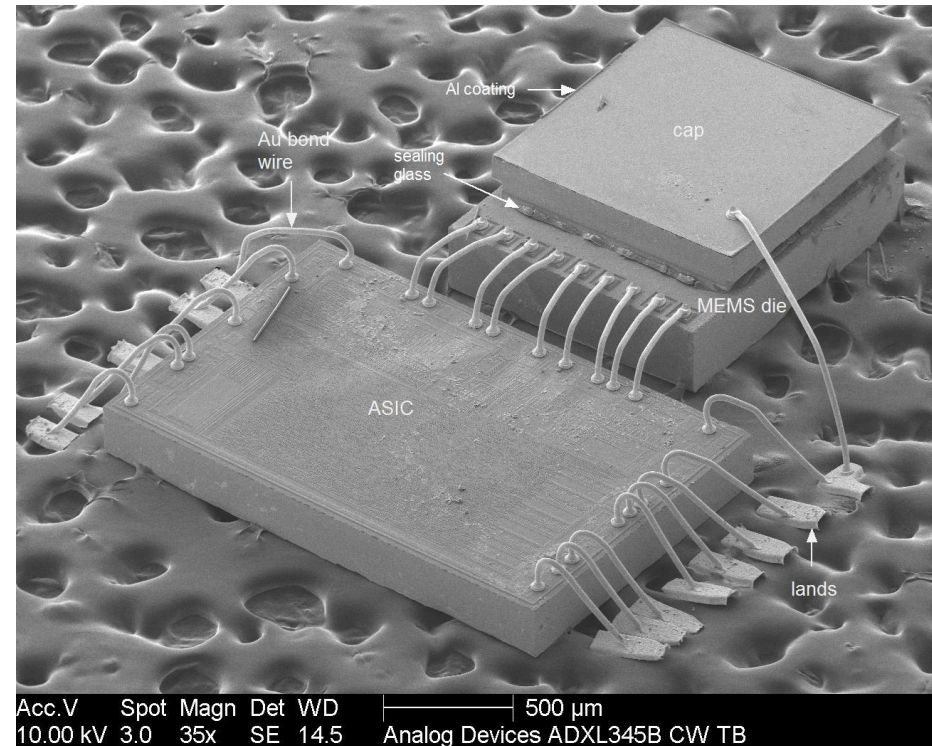
**For Best Performance: Calibration of each Axis is performed.
This eliminates small errors in finger / beam manufacture.**

Challenges of Testing MEMS Devices

Accelerometer Example



3 Axis Accelerometer: MEMS and ASIC Die



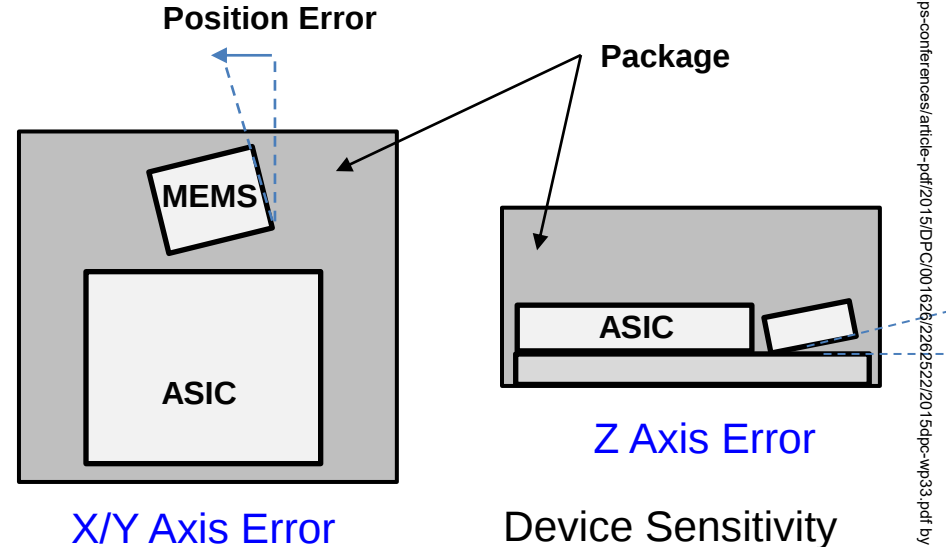
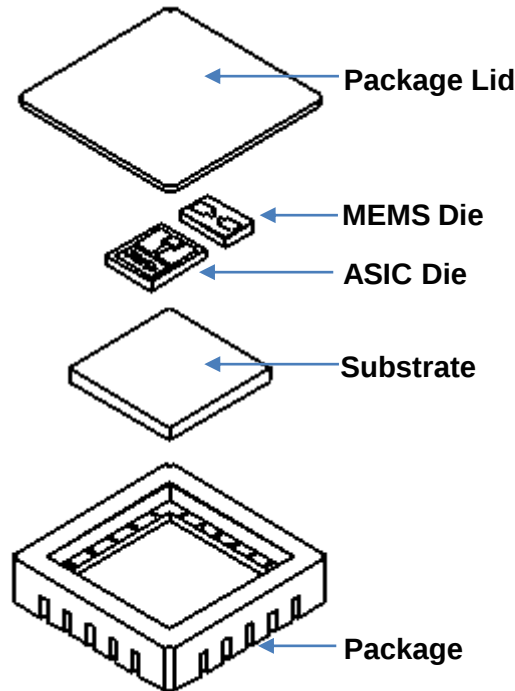
3 Axis Device = 3 Degrees of Freedom “DOF”

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Challenges of Testing MEMS Devices

Accelerometer Example

3 Axis Accelerometer: MEMS and ASIC Die



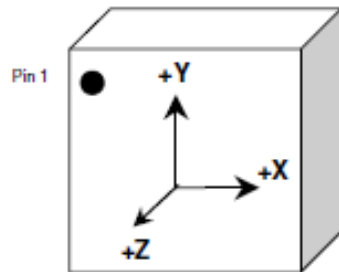
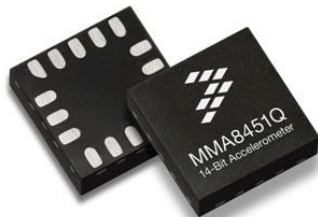
Device Sensitivity

Bits	LSB
8	1.4°
12	0.08°
16	0.005°

Challenges of Testing MEMS Devices

Accelerometer Example

The device senses movement in the X, Y, Z directions.
When in the “Home” position: $X = Y = 0g$ and $Z = +1g$.



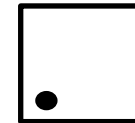
Home Position

Top



Bottom

$X = 0g$
 $Y = 0g$
 $Z = 1g$



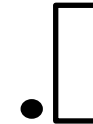
$X = 0g$
 $Y = -1g$
 $Z = 0g$

Bottom

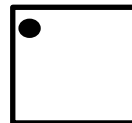


Top

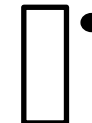
$X = 0g$
 $Y = 0g$
 $Z = -1g$



$X = 1g$
 $Y = 0g$
 $Z = 0g$



$X = 0g$
 $Y = 1g$
 $Z = 0g$



$X = -1g$
 $Y = 0g$
 $Z = 0g$

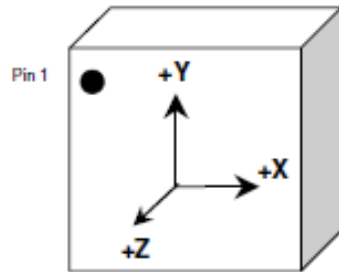


The device must be placed in 6 positions
to read all combinations of X, Y, Z outputs

Challenges of Testing MEMS Devices

Accelerometer Example

The device requires a “Calibration” pass followed by a “Verification / Test” pass. If 6 mechanical movements take on order of 3 to 5 seconds to execute...



Test Time = Mechanical motion + Electrical test + Mechanical motion + Electrical test

Calibration **Verification**

X	Y	Z
0	0	1
1	0	0
-1	0	0
0	1	0
0	-1	0
0	0	-1
0	0	1

Test Time = (3 to 5) + 1 sec + (3 to 5) + 1 sec

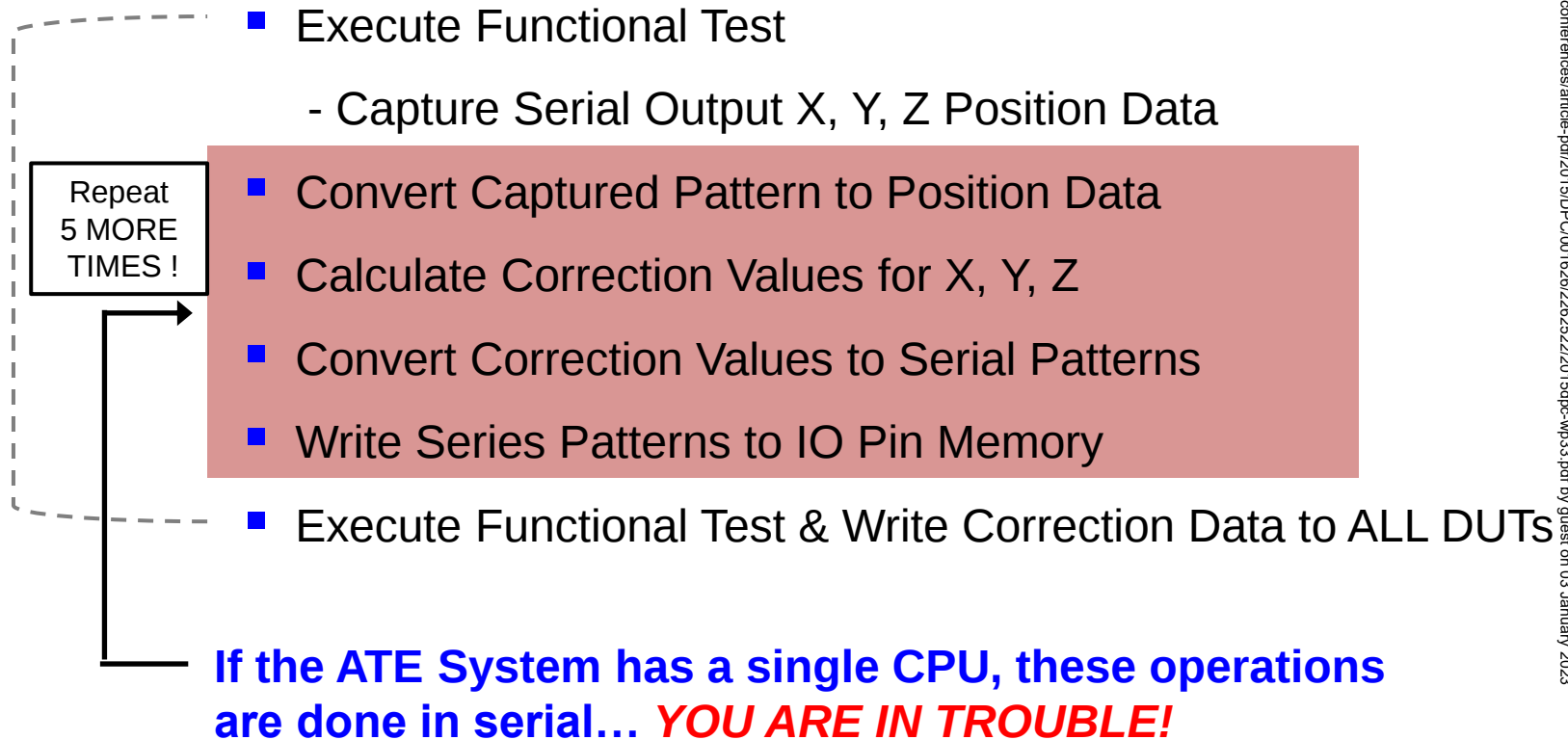
This can result in 8 to 12 seconds...

AND... did not add Temperature to the equation
... did not take ATE efficiency into account

Challenges of Testing MEMS Devices

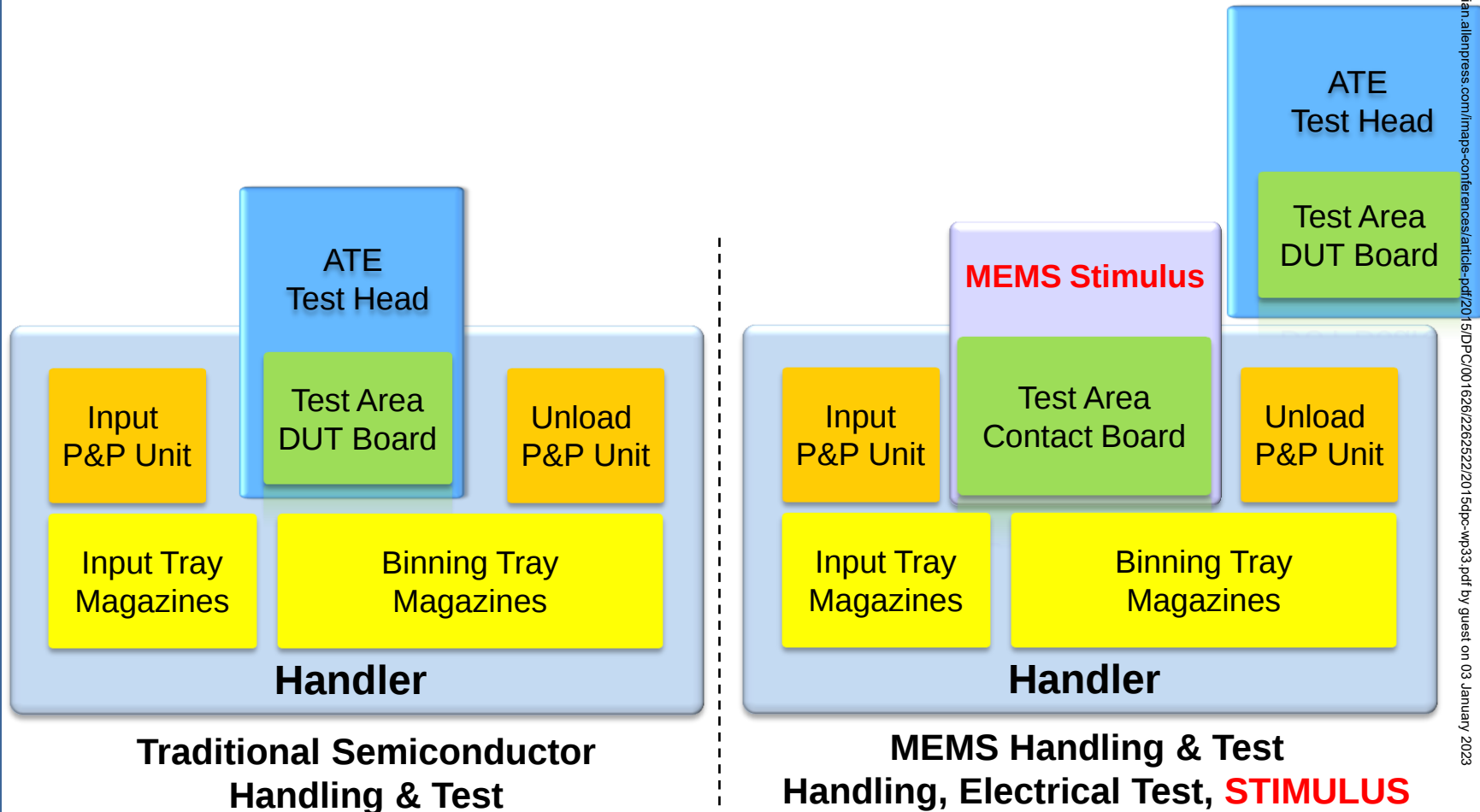
One More Thing...

For Initial Device Calibration!



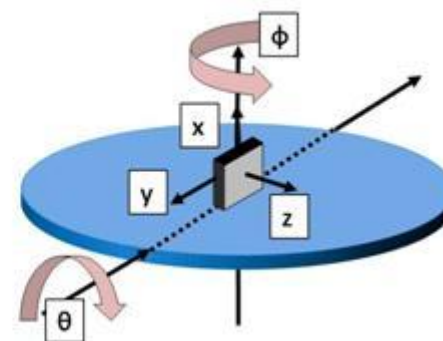
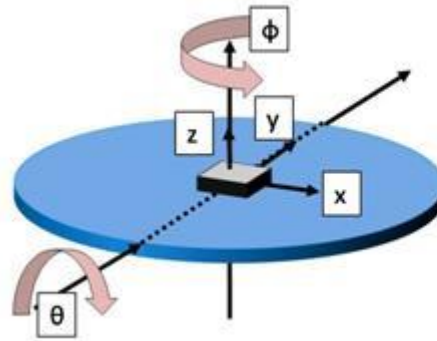
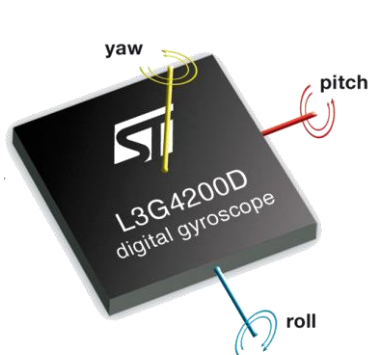
Challenges of Testing MEMS Devices

So What's THE PROBLEM ?



Challenges of Testing MEMS Devices

What about Gyroscopes ?

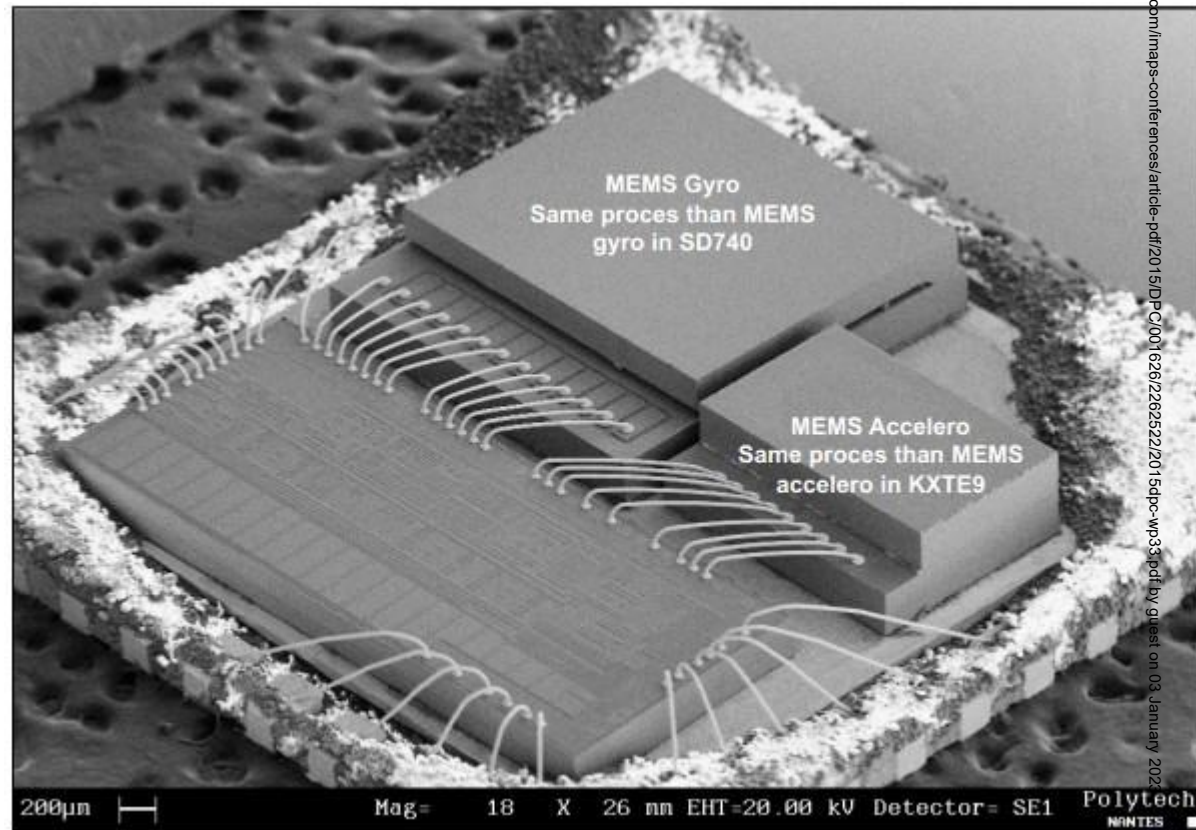
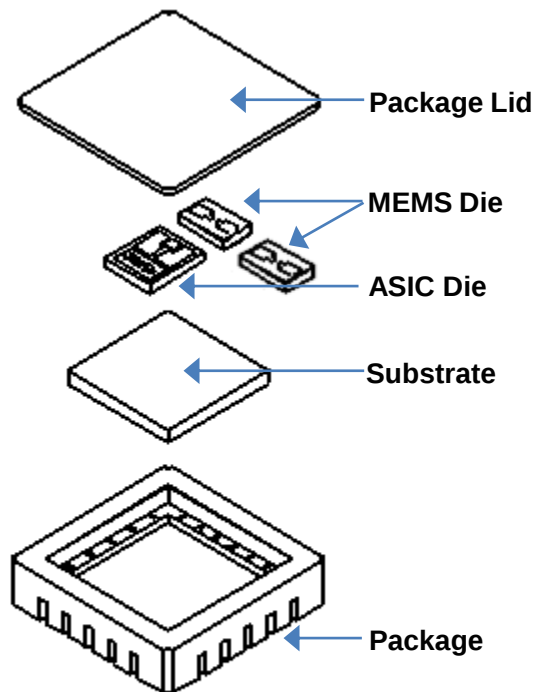


Gyroscopes require Rotational Stimulus
Tri-Axial Gyroscope = 360° Rotation for each Axis

Challenges of Testing MEMS Devices

Combo Example

“COMBO” with Accelerometer, Gyroscope, ASIC



Two 3 Axis Devices = 6 Degrees of Freedom “DOF”

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Challenges of Testing MEMS Devices

MEMS Package Trends...

- Smaller Package Size - Less Pins
- Multiple Packages: CSP vs BGA vs LGA vs SOIC vs
- Multiple Sensors in a Package - More Functionality
- Multiple Sensors
 - Tight Die Placement Tolerance
 - Multiple Stimulus Requirements
 - Longer Test Times
 - Temp Sensors for Thermal Correction

Handling & Test is the largest contributor to the Selling Price “ASP” of a MEMS Sensor!

MEMS Testing: The Complete Solution



Stimulus

Process specific input
Flip, rotation, vibration,
pressure, light...

Thermal Conditioning

-40° to +125°C
Highly Accurate ($\pm 1^\circ\text{C}$)

Fixture

DUT electrical contact
DUT mechanical clamp
Signal IF to ATE

Reporting

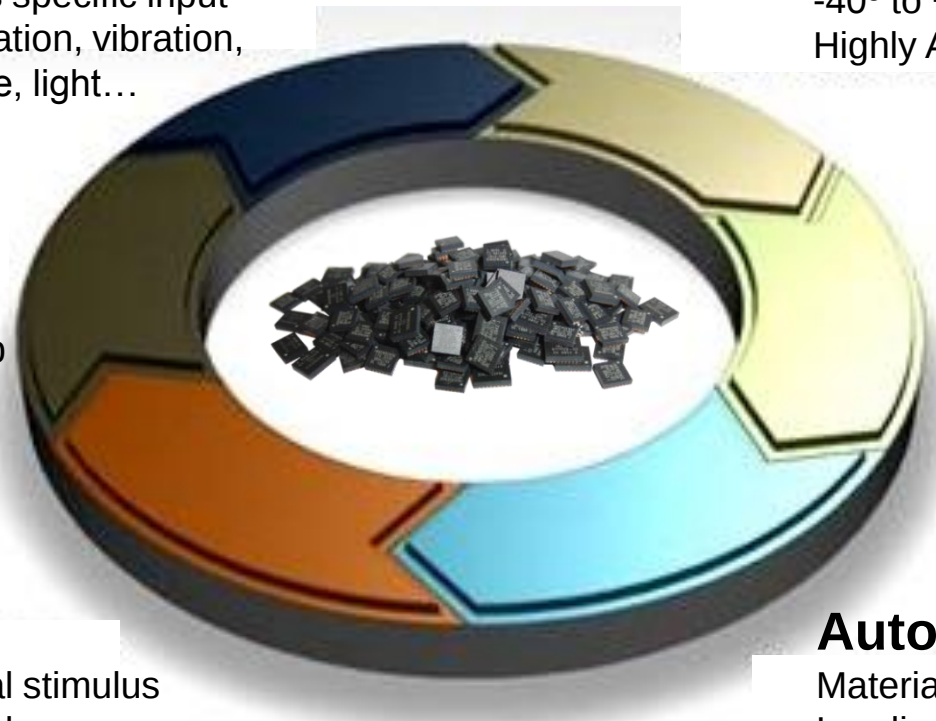
Database
Analysis Tools

ATE

Electrical stimulus
Electrical response
Overall system control
Measurement instrumentation

Automation

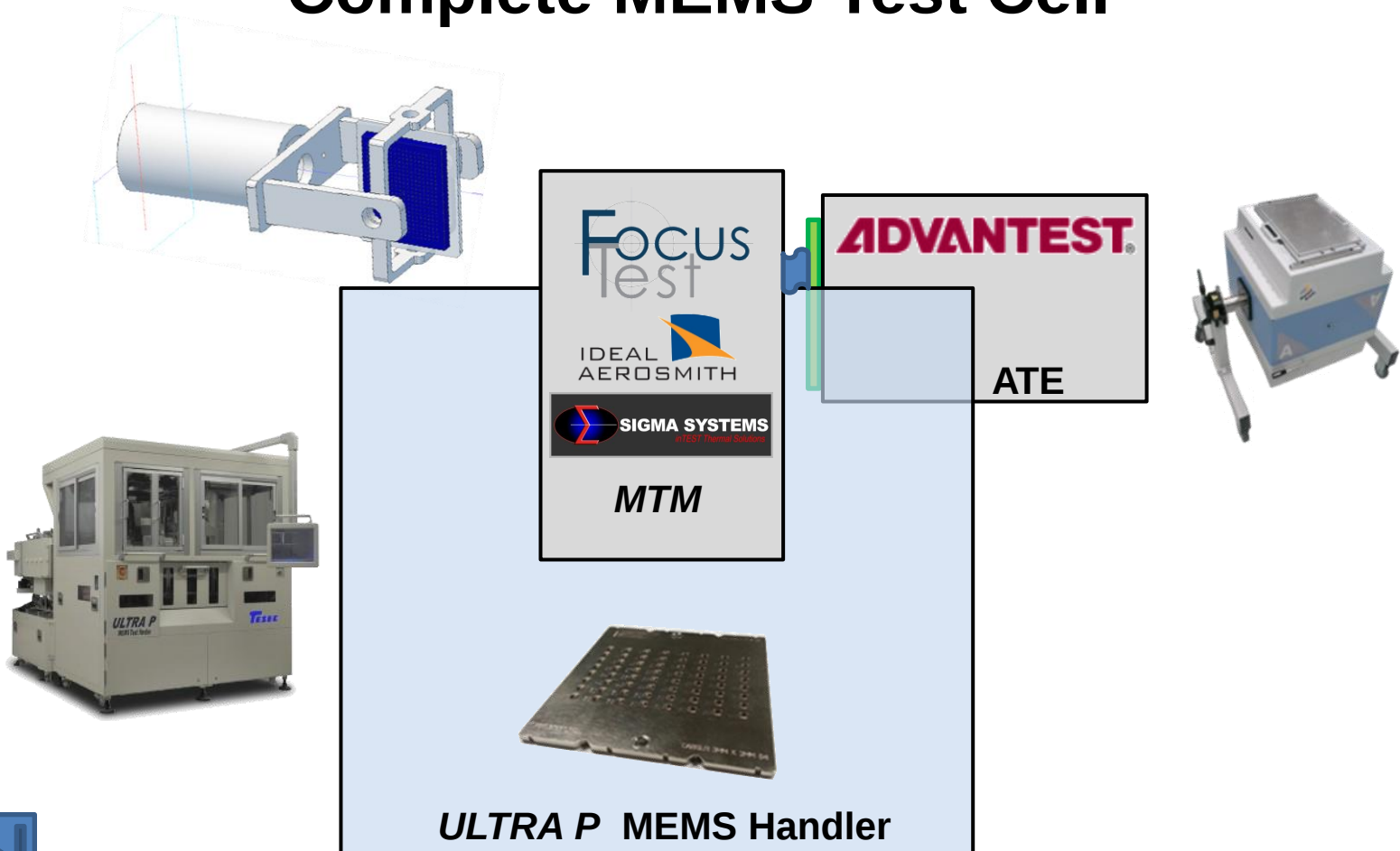
Material movement
Loading/Unloading
DUT tracking
Binning



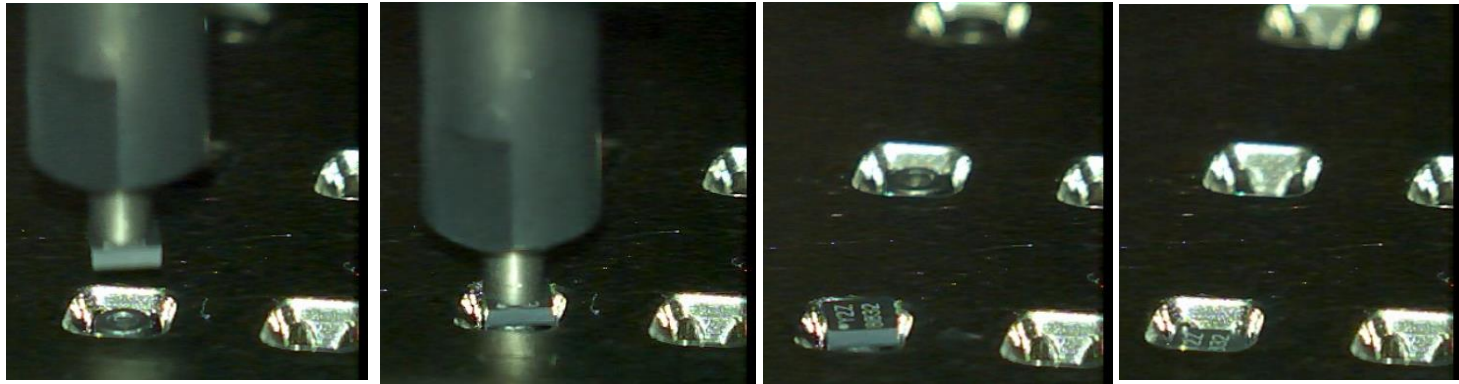
Challenges of Testing MEMS Devices



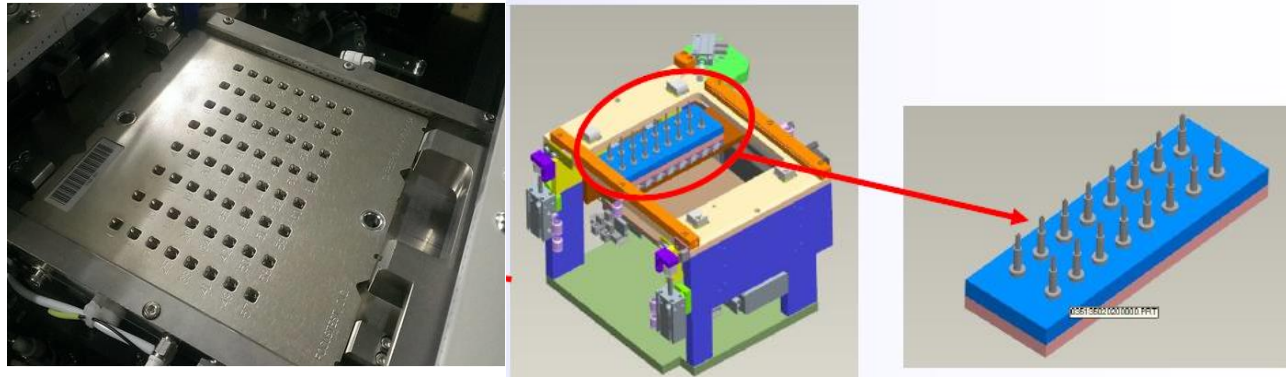
Complete MEMS Test Cell



SSDP: “Super Small Device Placement”



- **Provides Accurate and Reliable Pick & Place for Small DUT Packages**



- **Higher Accuracy and Reliability**
- **Lower Jam Rates**
- **Smaller Package Size Capability**

* Patent Pending



Challenges of Testing MEMS Devices

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Thank you!



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