EIGHTEENTH ANNUAL

BiTS™

Burn-in & Test Strategies Workshop

March 5 - 8, 2017

Hilton Phoenix / Mesa Hotel
Mesa, Arizona

Archive – Session 5

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BiTS 2017 Burn-in & Test Strategies Workshop

Session 5

Rahima Mohammed

Session Chair

BiTS Workshop 2017 Schedule

Frontier Day

Tuesday March 7 - 10:30 am

Heating Up

"Process Improvements to Increase Burn-In Yield and Quality"

Jeanette Linn, Rich Karr - Texas Instruments

"Device Characterization Over Temperature at the Board Level"

Barry Johnson - inTEST Thermal Solutions

"Qualifying A Process For Higher Burn-In Voltage Application"

Krishna Mohan Chavali - Globalfoundries US Inc

"Coming Challenges and Opportunities for MEMS Testing Supply Chain"

Wendy Chen - KYEC

BiTS Burn-in & Test Strategies Workshop 2017

Coming Challenges and Opportunities for MEMS Testing Supply Chain

Wendy Chen
KYEC

BiTS Workshop
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Content

- The Challenges – Past , Present and Future
- Change & Motivation
- The Opportunities
- Summary

Challenges

MEMS Testing - Supply Chain

Past - Present - Future

Market Value Forecast is Unpredictable

MEMS Sensor Consumer Device

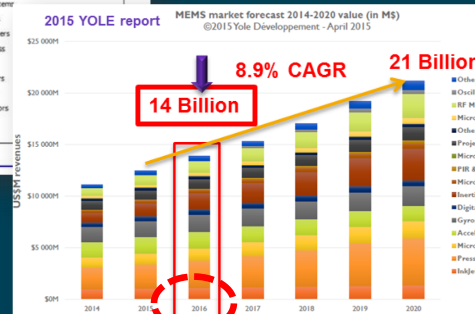
- Market Shipments Forecast - 40% annual growth rate is consistent and on a predictable track
- The Market Value Forecast is inconsistent and unpredictable.

✓ Year 2011 forecast 2016 → 19.5 Billion US$

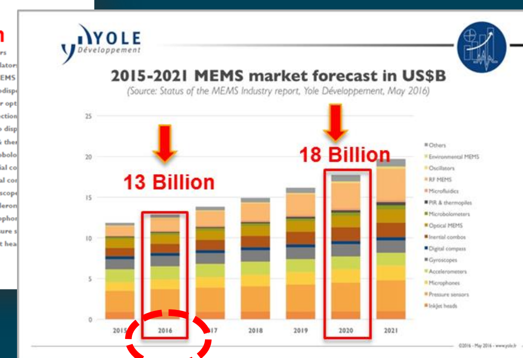
✓ Year 2015 forecast 2016 → 14 Billion US$

✓ Year 2016 May update forecast → 13 Billion US$

2016



2016



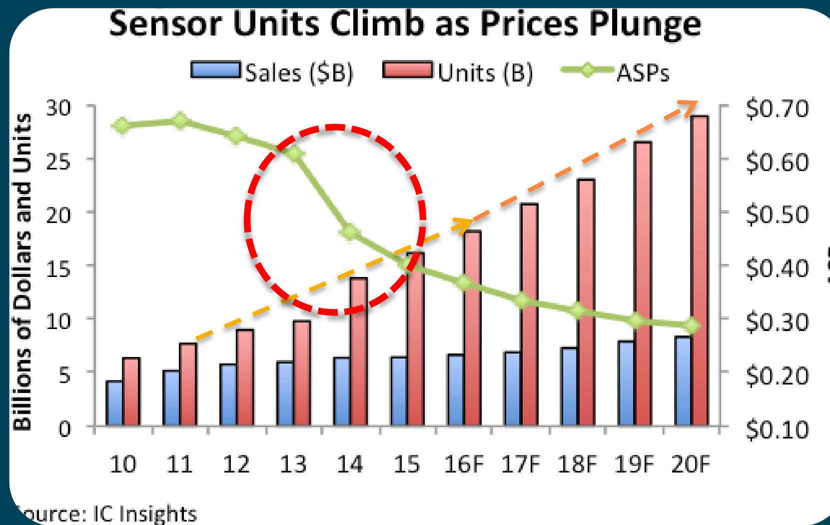
2016

Courtesy of Yole

ATE Capital Investment is Risky

MEMS Sensor Consumer Device

- Market research IC Insights also pointed out continuous growth of the MEMS market.
- ASP drops down dramatically.



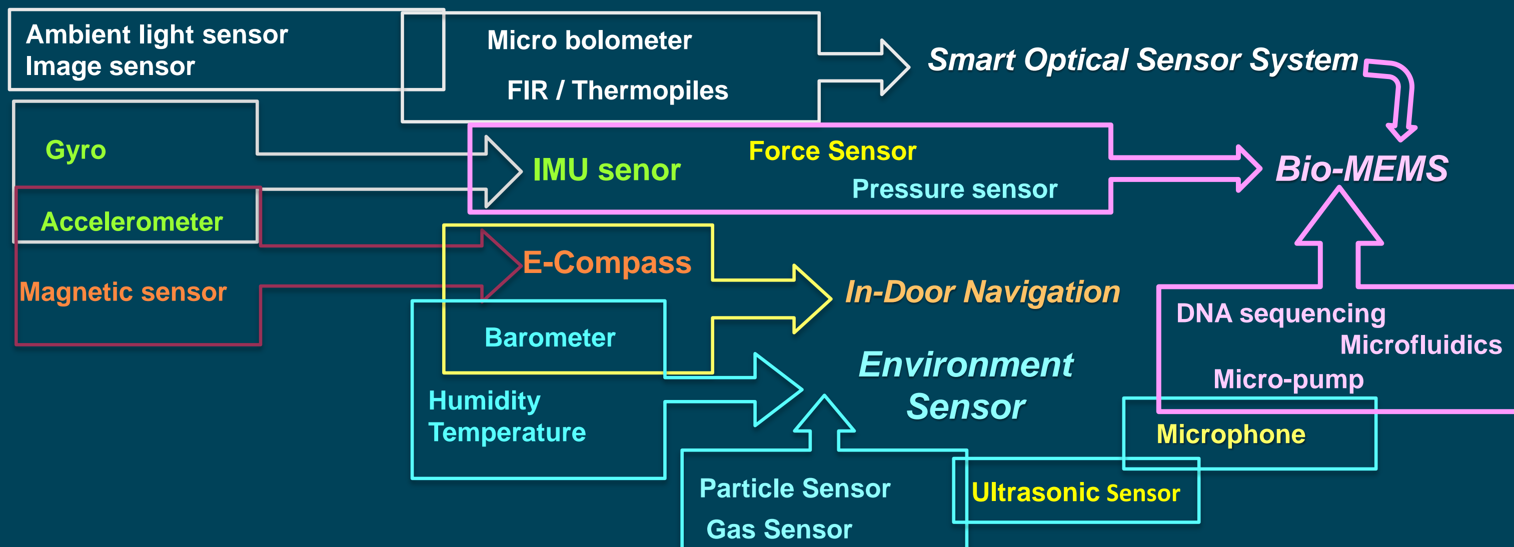
How to extend test capacity Still gain profit ?

WHAT HAPPENED ASP DROP DRAMATICALLY DURING 2013-2015 ?

Fusion, Combo Sensor - Trends

- The growth of the MEMS market also pushes to drop down ASP.
- Combo Sensor brings added value and slows down ASP erosion

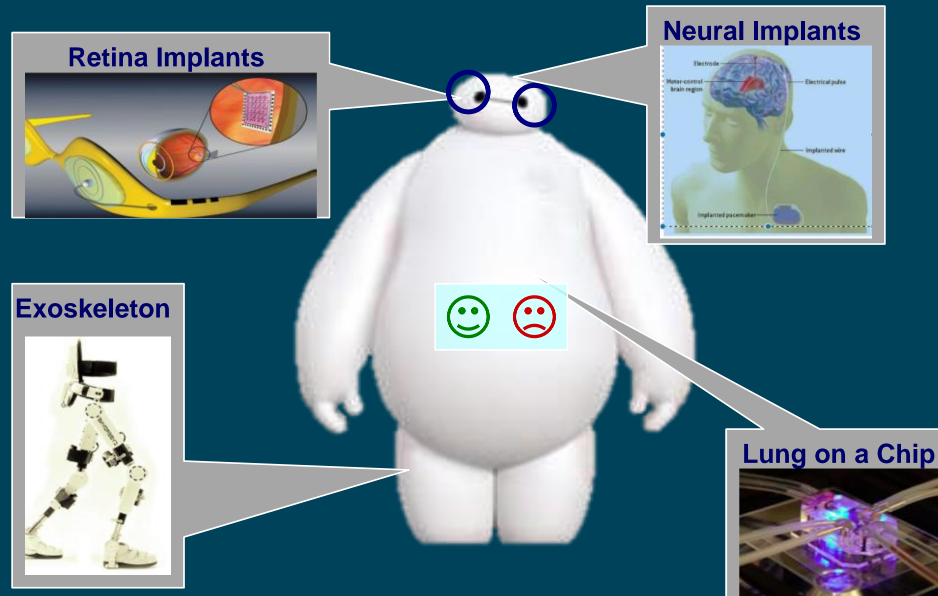
Challenges - The Test Complexities Raise Up



Automobile and Bio-MEMS

- The upcoming stars of MEMS applications are Automobile and Bio-MEMS.
- A multitude of MEMS sensors were adopted by automotive assistant and sensing systems. The Market is growing at a stable rate.
- The new innovations of Bio-MEMS Sensor extend to personal healthcare.

Challenges - Reliability is getting important !!



Coming Challenges and Opportunities for MEMS Testing Supply Chain

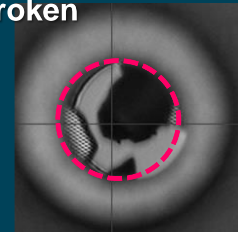
MEMS Sensor Failure Mechanism is different from CMOS IC

MEMS Sensor Fail Mechanism

Packaging Problem

Mechanical Defect

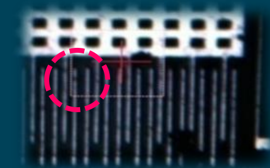
Membrane broken



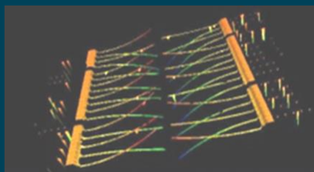
Thermal Stresses by mismatch of CTE

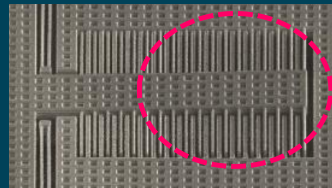
Excessive Intrinsic Stress

Sensing electrode sticky



Vertical Curl on sensing electrode

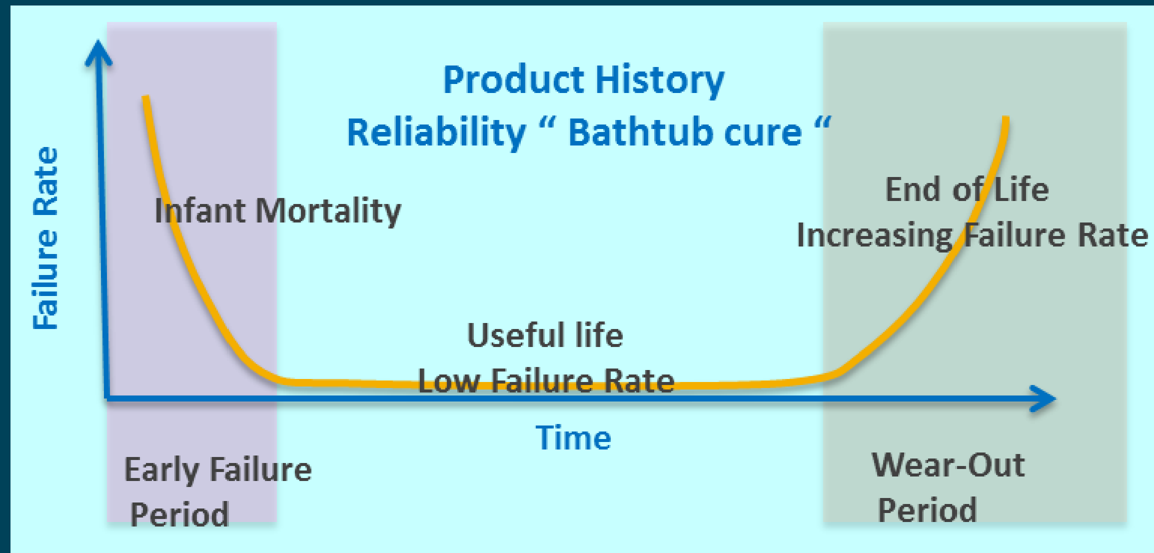




Lateral Curl on spring

Challenges- MEMS Sensor Burn In Test

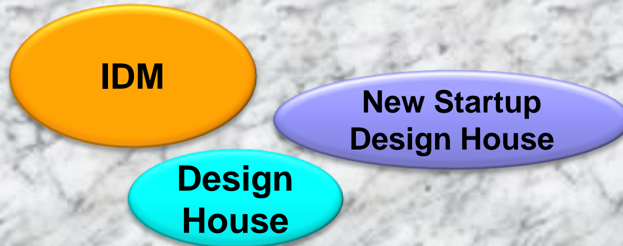
- Different MEMS Structures need different Physical Stress to Accelerate Early Failure Period.
- The Cost of Burn In / Test Fusion MEMS Sensor is High.



“Change & Motivation”

MEMS Manufacture Supply Chain

MEMS Sensor Provider



Trend

- ✓ Fab-light or Fabless
- ✓ MEMS manufacture: Vertical Integration Supply Chain
  - Wafer Foundry
  - Testing Service
  - Assembly &Packaging

MOTIVATION

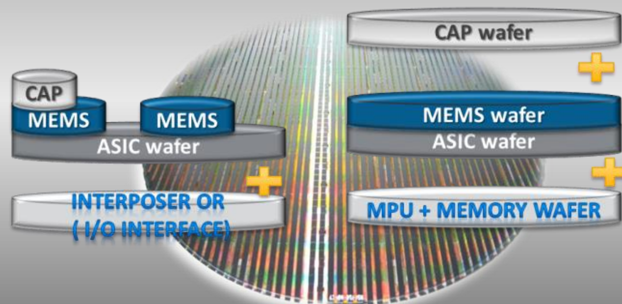
Outsource to Supply Chain

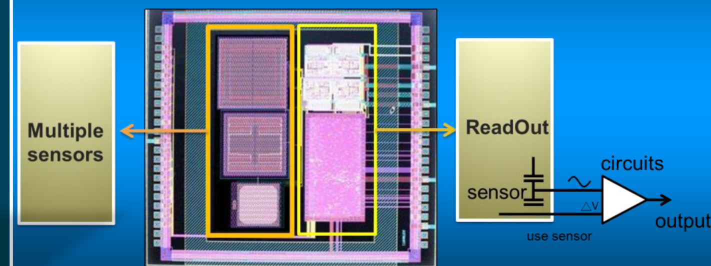
Share Intelligent Property

Share Investment Risk

Share Intelectual Property

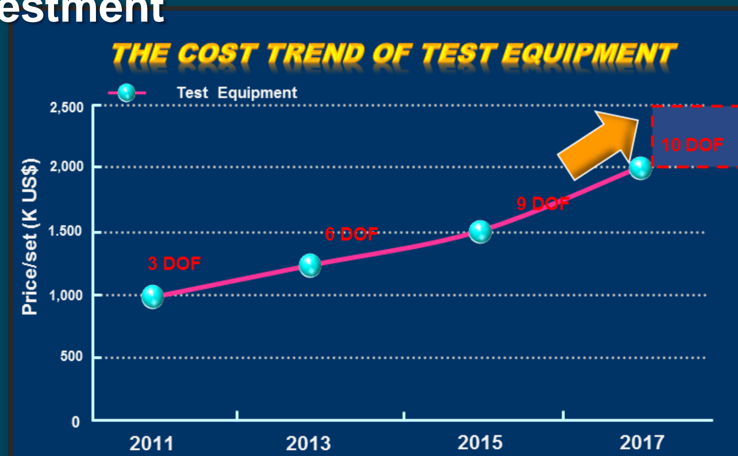
- 3DS Process innovation: Multi- MEMS Sensors integrate with ASIC and I/O interfaces such as RF through 3DS process.
- CMOS MEMS process innovation : MEMS and ASIC SOC process using CMOS platform



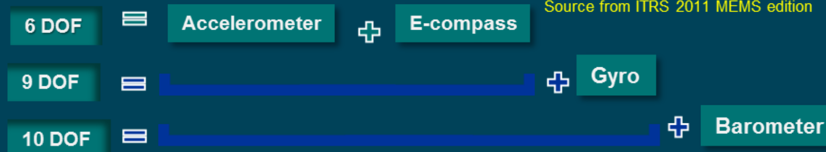


Share Investment Risk

- The Fusion Sensor performances advance very rapidly. But the cost of ATE capital is increasing due to test and handling complexities.
- Test service foundries could share their ATE capacity between many customers and optimize test procedures reducing the risk of investment



Source from ITRS 2011 MEMS edition



Test service foundry

The Opportunities

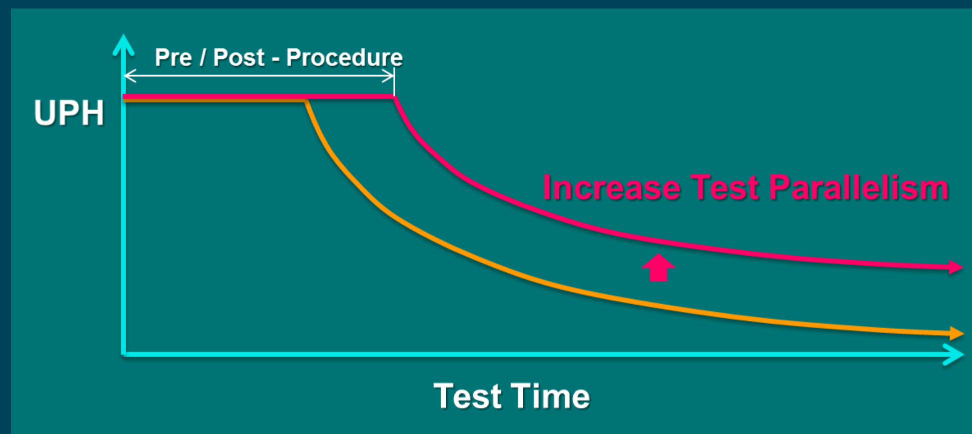
MEMS Testing Supply Chain

Test Cost Reduction

- Increase Test Parallelism to improve UPH
  - ✓ Drawback : Jam rate ↑ , OEE ↓ (Test Time < Pre/Pro- Procedure)

UPH(unit/hrs.) = Minimum (Pre-procedure, Post-procedure , Test-procedure)

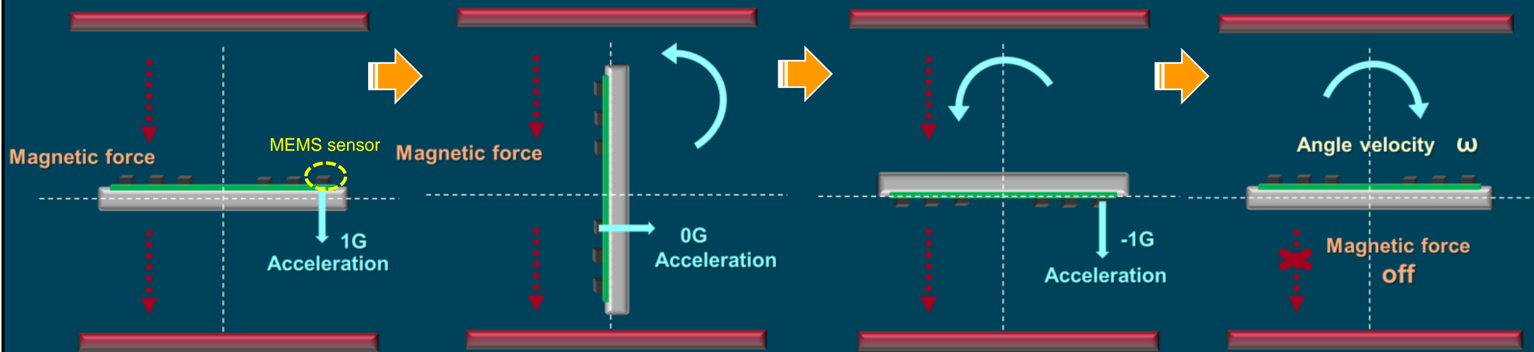
$$\text{Test-procedure UPH} = \frac{3600\ \text{sec}}{\text{Test Time + Index Time}} \times \text{Number of test sites in parallelism}$$



Test Cost Reduction

- Simplify the Test Procedure to Reduce Test Time
  - ✓ Integrate multiplex stimulus to test Combo MEMS sensor
  - ✓ Drawback : Test Coverage rate goes down

Case: Test combo sensor (Accelerometer + Gyro + Magnetic Sensor)



New Innovation for Test Cost Reduction

Increase test parallelism

Reduce test time

Not Enough

Innovative way

to overcome upcoming challenges

MEMS DFT (Design For Test)
(BIST + BISC+ BISD)

MEMS Expert

No, impossible (2010)
A few, conditional (2012)

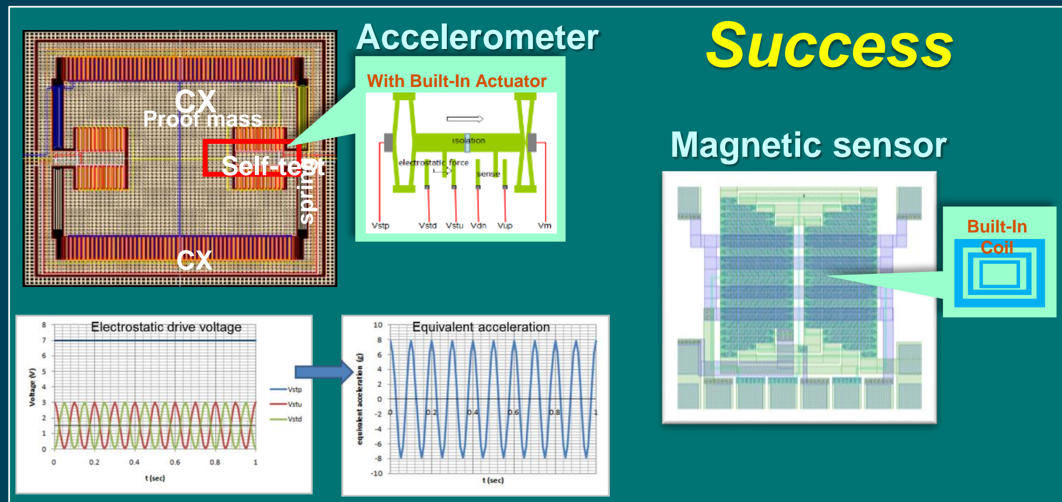
MEMS Company CEO

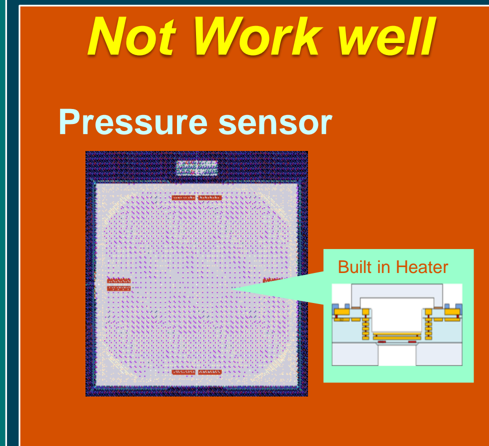
Yes, It is trend (2013)

Vision is important!!
We should prepare
and
ready for change

MEMS BIST Concept

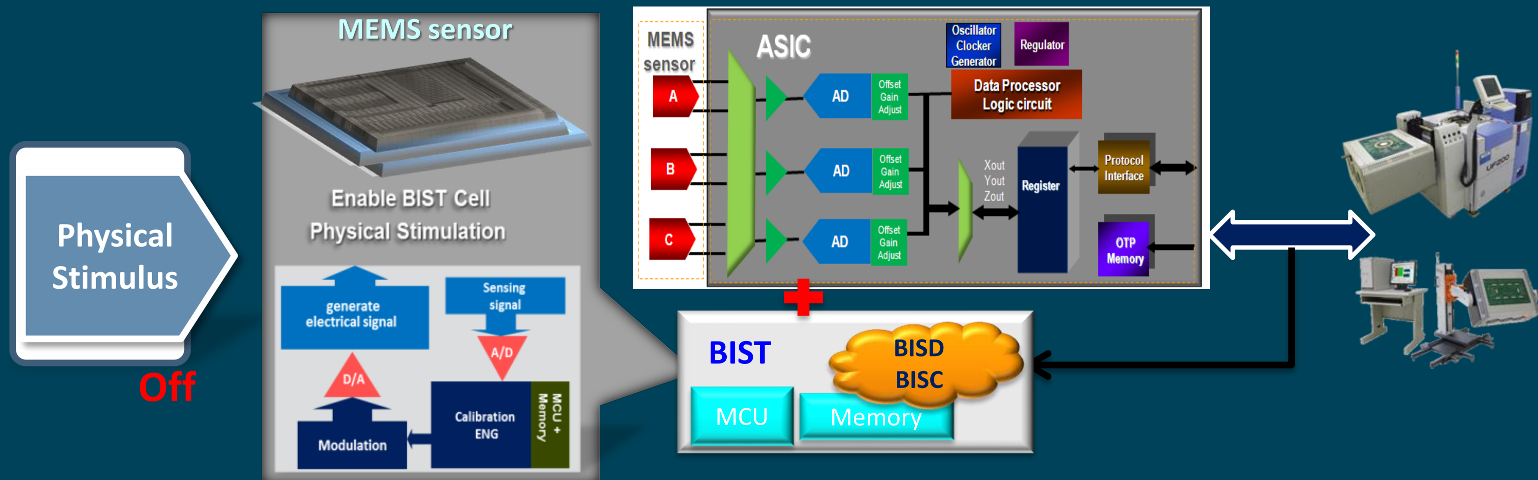
- MEMS Built In Test Concept is developing stimulus source and sensor in the same MEMS structure cell.
- Electrical actuator type of BIST structure has already been successfully implemented. Membrane type of BIST are not production ready at this time.





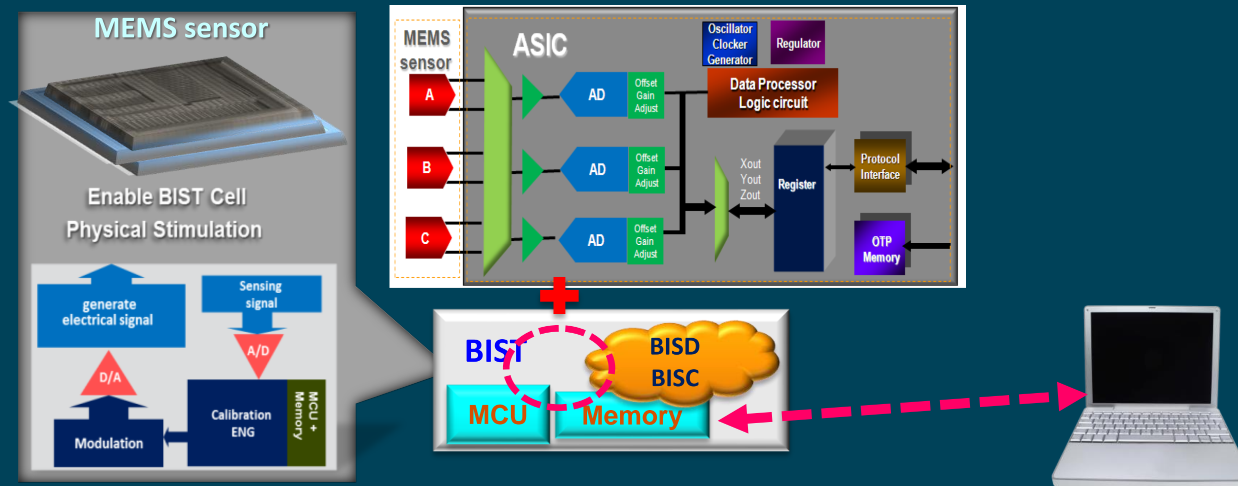
MEMS Innovative Test Concept

- Build In Self Test Cell include physical stimulus structure and control circuit.
- The cloned Physical Stimulation signal will be generated from ASIC to Enable BIST cell.



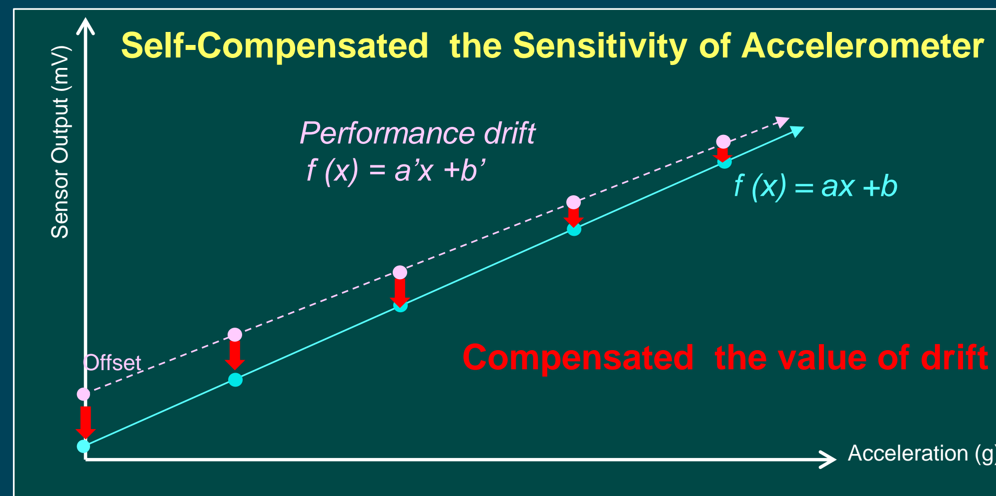
BISX provides Effective Reliability Solution

- Develop Smart Firmware to Enable DFT/BIST for Improving MEMS Sensor Performance.



BISX provides Effective Reliability Solution

- BISD turns on BIST to diagnose the performance of offset value and sensitivity of MEMS sensor structure. If the performance is drift, BISC will calibrate structure or compensate the value of drift to keep the consistent performance of MEMS sensor.

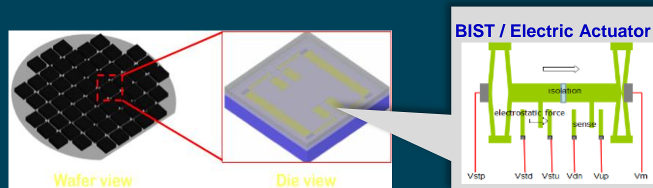


MEMS Sensor Burn In Test

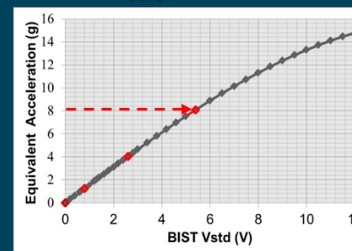
- MEMS Sensor Wafer Level Burn In :
  - ✓ Combo MEMS Sensor increases Complexities and Test Cost.
  - ✓ MEMS DFT/BIST provides Cost Effective Solutions.

- MEMS Sensor Package level Burn In Test:
  - ✓ Standard IC Burn In Solution + System Level Burn In
  - ✓ DFT/BISD+BISC(Calibration/Compensation) to increase Reliability

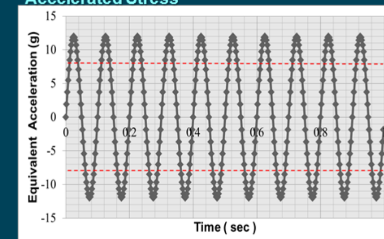
Case :
Accelerometer applied BIST to Wafer Level Burn In Test



DC driving mode:
Good to apply to Wafer Level Test



AC acceleration mode:
Good to apply to Wafer Level Burn In Test
Accelerated Stress



Summary

- *Consumer MEMS Sensor drive 1st wave of Evolution*

  Smart Living push The 2nd wave of Evolution of MEMS Sensor.
- *Test Challenges of MEMS Sensor become more Difficult.*
- *Cost Reduction motived Change and Innovation.*
- *DFT open new solutions for upcoming Reliability Challenges.*
- *New innovations of MEMS architecture motivated to share Capacity of Semiconductor Supply Chain*

OPPORTUNITIES COME FROM CHANGES & CHALLENGES