

# Application based testing of MEMS devices

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**30/31 MEI & 1 JUNI 2017  
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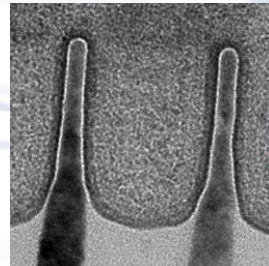
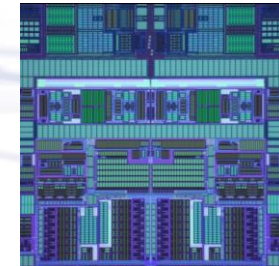
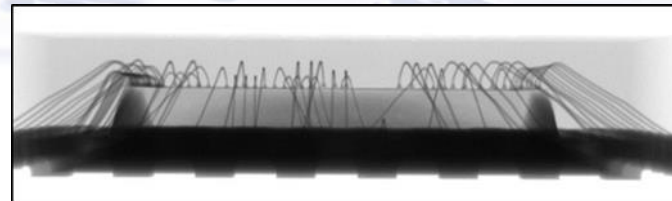
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## Introduction

- Independent Test & Diagnostics of Microelectronics
- Failure Analysis services for IC's and electronic components
- Reliability Test services, full product qualification and ESD/LU tests
- Supply Chain consultancy in IC and MEMS back-end manufacturing
- ISO9001 certified and ISO17025 accreditation (RvA L388)
- Founded in 1993, 43 employees (>60% engineering degree)
- 1900m<sup>2</sup> office & laboratory at Kennispark Enschede, NL
- 5 representations covering EU and IL
- 120+ semiconductor device manufacturers (IDM+fabless)



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# MEMS classes

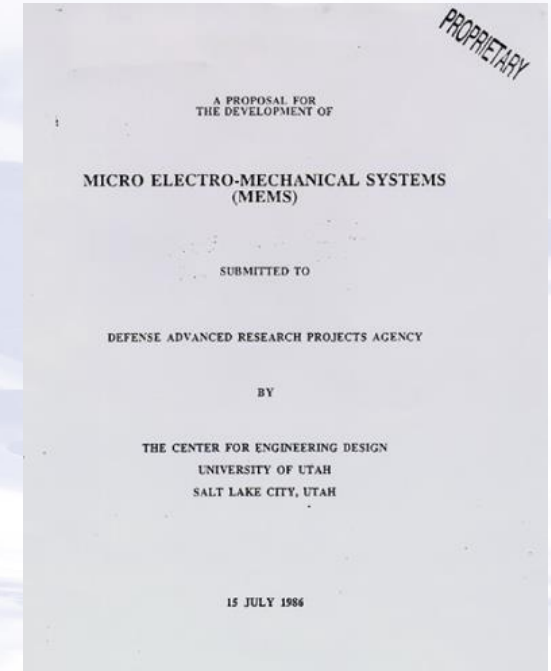
→ **Micro Electrical Mechanical System, since 1986**

## ■ Sensing

- Mechanical → inertial sensing / pressure
- Magnetic → compass
- Optical → image sensors
- Chemical → moisture / chemicals / molecules

## ■ Actuating

- Micromotors quasi-static or free moving
- Microfluid controllers
- Optical switching



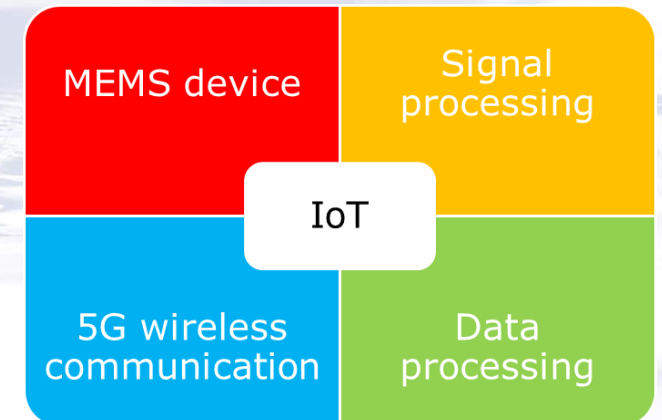
Proposal to DARPA by Utah University





# MEMS classes

- **Future Integration of MEMS → IoT applications**
  - MEMS – Signal and Data processing – RF communication – Power
  - Advanced semiconductor processing (<10nm+mixed mode+5G)
  - Extension of smart phone: data processing and RF communication
  - Autonomous network of MEMS connected to 5G cloud database
- **Energy management**
  - Energy harvesting to power small MEMS
  - Ultra low power for >10year battery life
  - 24/7 operation for monitoring functions



# Electrical Test / Physical Test

- **Semiconductor industry production volume test**
  - Wafer level E-test → packaging → Final product E-test
- **Automated Test Equipment**
- **Automated wafer handlers**
- **Parallel device test handlers**
- **Large OSAT infrastructure**
- **MEMS industry volume test**
  - Only Electrical, no Physical domain
- **MEMS sensing/actuating conflicts in electrical domain**

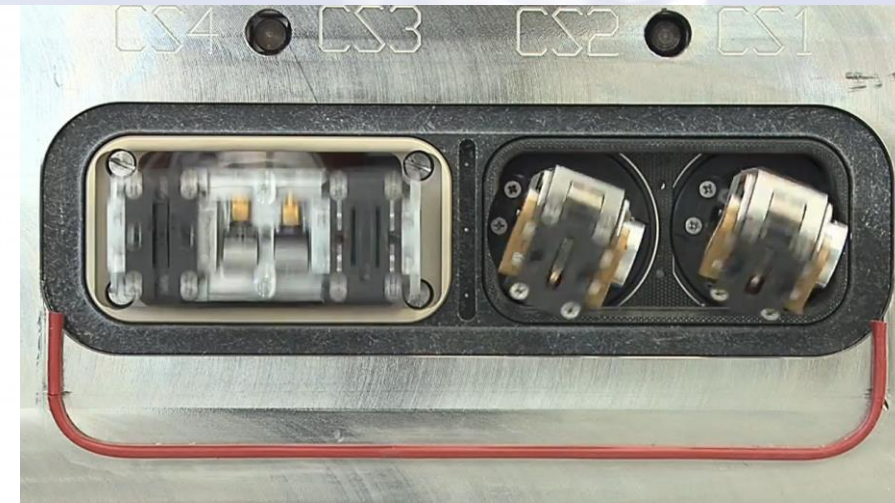


Courtesy Salland Engineering NL



# Electrical Test / Physical Test

- **MEMS test dilemma**
  - Volume production with multiple electrical contacts interfere with movements or harsh environmental stresses or optical parameters
  - Mechanical / Optical / Chemical stress not available on wafer test
  - Package costly part of MEMS
- **Current applications**
  - No or limited wafer test
  - Limited OSAT infrastructure
  - Low throughput units/min
  - Mainly mechanical sensing apps



Courtesy Xcera Corp. USA





# MEMS Behavior Analysis

- **Goal: use electrical parameters representing physical MEMS parameter conversion behavior**
- **Allows MEMS wafer level analysis**
  - Faster wafer yield feedback → faster product development cycles
  - Improved test yields and product quality
  - Reduction of costs due to packaging of bad MEMS
- **Electrical Characterization under Physical stress**
  - Simulation of sensing circuitry response to electrical stimulation
  - Extract electrical parametric behavior to mechanical sensing
  - Extensive characterisation program to prove correlation

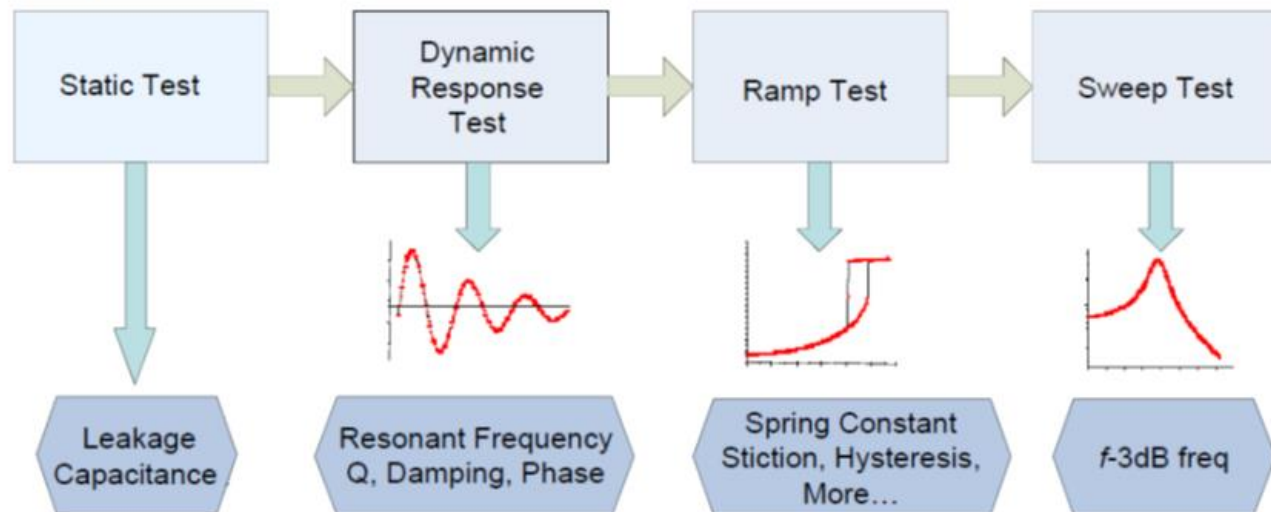




# Electrical Characterization

- Many MEMS devices use capacitive change for sensing
- Combined with static I/V
- Dynamic Level testing

Example Test Flow



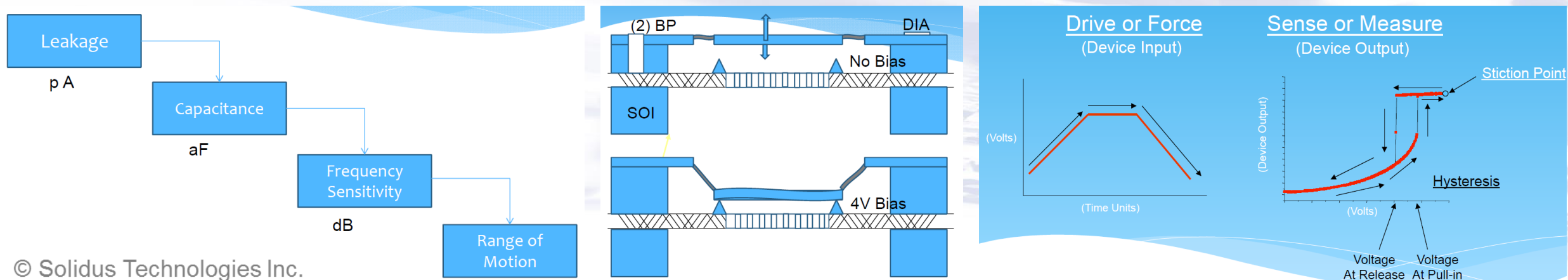
Example Test Output

product / parameter	Accelerometer	Gyroscope	Magnetometer	Microphone	Pressure Sensor	Tactile Sensor	Light Sensor
Leakage							
Capacitance							
Sensitivity							
-3dB Roll-off							
Q-factor							
Quadrature							
Step response							
Damping							
ROM							



# Electrical Characterization

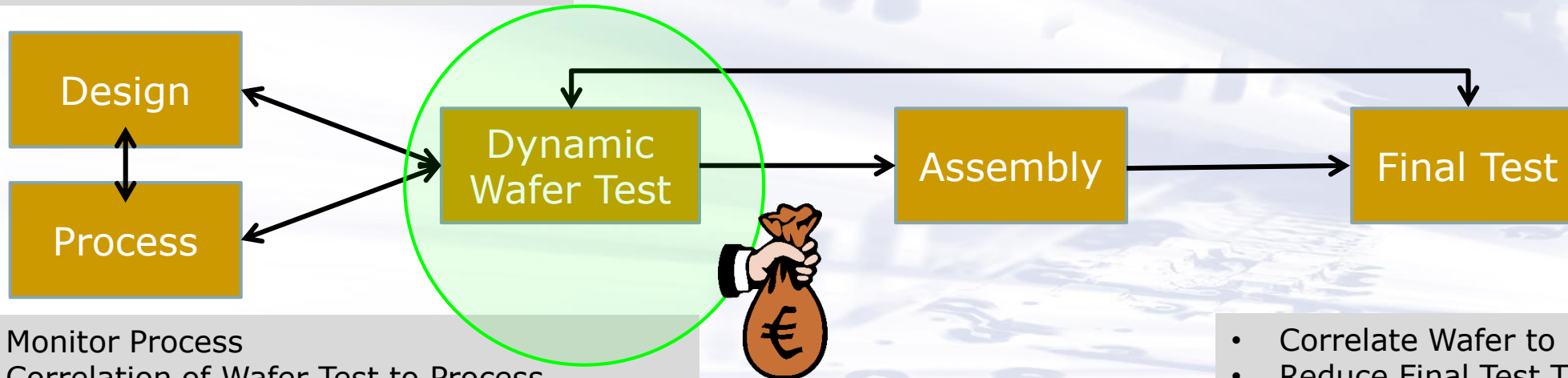
- Example: MEMS microphone wafer level test
- Dedicated measurement tools near probe card
- Range Of Motion test to find potential reliability hazards
- Test flow including I/V, FFT analysis and ROM test



# Electrical Characterization

## MEMS Manufacturing Value with Dynamic Wafer Test

- Design Feedback
- Improve Design
- Match Design with Process
- Match Design with Test Performance



- Monitor Process
- Correlation of Wafer Test to Process
- Reduce Process Variation
- Validate Process with Wafer Test Distribution
- Sort for Performance

- Correlate Wafer to Final Test
- Reduce Final Test Times
- Reduce Final Tests
- Improve Final Test Yields
- Increase Units Per Hour

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# Qualification and Production Test

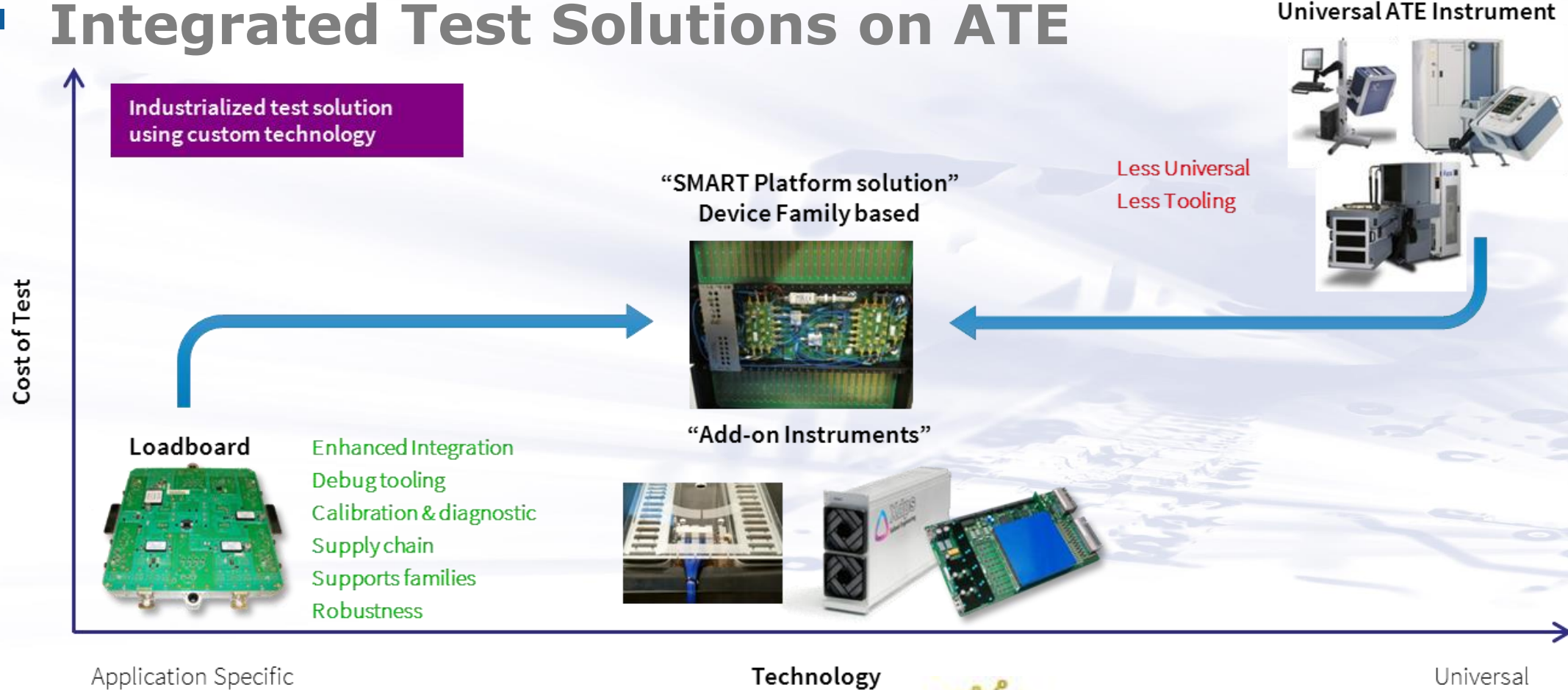
- **Qualification test procedure**
  - Chip/MEMS related stress tests
  - Package related stress tests
  - Physical Construction Analysis
- **Real world simulation**
  - Tyre pressure sensor @ 230km/h
  - Constant acceleration test  
60 units, 24 hours / axis, 6 axis
  - Electrical monitoring test





# Qualification and Production Test

## ■ Integrated Test Solutions on ATE



Application Specific

Technology

Universal

Courtesy: Salland Engineering NL



# Summary

- **MEMS devices are an important class with high growth**
- **More devices require improvements in the supply chain**
- **MEMS play an important role in autonomous systems**
- **New MEMS technology find new application area's**
- **Dynamic Wafer Level testing is a good novel approach**
- **Combined with extensive correlation and qualification test this approach offers best in class MEMS devices**
- **R&D and DfT efforts needed to expand the e-test application during volume production testing**



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