Accelerate Your MEMS Device Development and Manufacturing Efficiency Using

Agilent's Best-In-Class Impedance Test Instruments

Agilent Technologies

Introduction

Micro Electro Mechanical Systems (MEMS) is the technology to build very small structures whose ranges are generally from a millimeter to a micrometer. NEMS (Nano Electro Mechanical Systems) is similar but its range is in nanometers. A MEMS/NEMS structure is an integrated device, on which movable parts such as sensors, actuators, and electronic circuits are built using MEMS/NEMS technology.

Agilent Technologies offers several instruments to improve test efficiencies of MEMS/NEMS devices, using state-of-the-art impedance techniques throughout the design and manufacturing processes. Agilent can help you to establish more accurate device modeling, more efficient failure analysis, and better process controls using these instruments.

Test Challenges

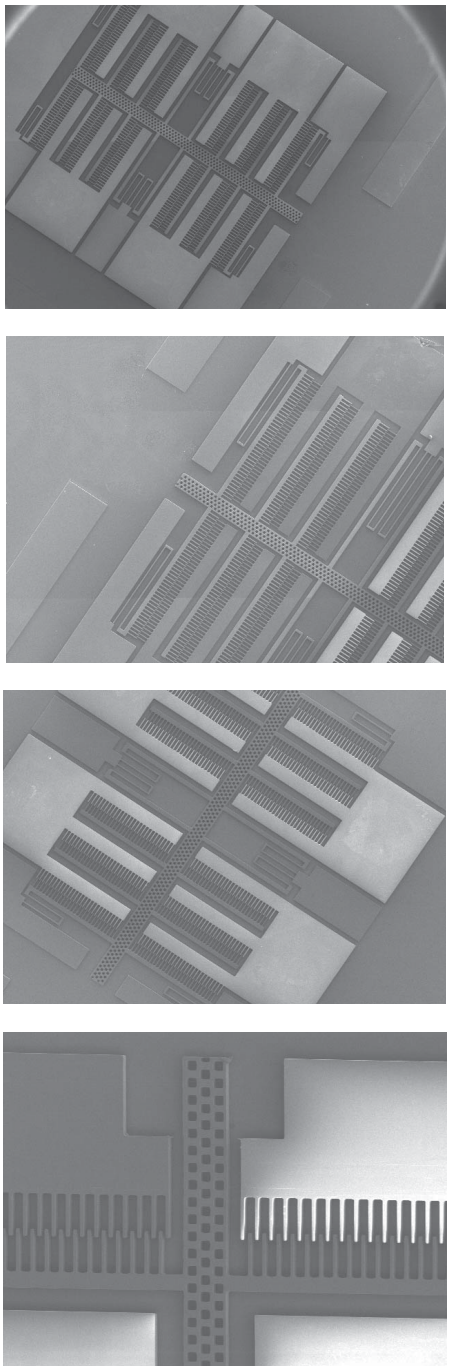
MEMS technology involves working with very small, precise, micro-fabricated devices. As such, testing MEMS devices requires very accurate test instruments.

MEMS business in general is growing rapidly and so are the associated cost pressures in making it a viable technology. Testing as early in the process as possible is a key factor in lowering the production cost. The throughput and yield are the most important parameters in the mass production test.

The throughput of MEMS devices is usually slower than traditional devices because the devices are tested by mechanical stimuli such as pressure, acceleration, and/or sound waves. Electrical tests such as impedance measurements do not require these mechanical stimuli so throughput can be improved.

The repeatability of the tester is key to improving yields. While the stability of mechanical stimuli is difficult to control, electrical stimuli and measurements are easier to maintain, which improves repeatability.

Electrical wafer test is the best way to compress the production cost of a MEMS device, and Agilent impedance analyzers and testers are the best tools for this purpose with their excellent speed, repeatability and accuracy.



MEMS images courtesy of G. Jaramillo, M. Chan, and D. Horsley, University of California at Davis

Test Applications

The following are some typical tests performed on MEMS devices.

Mechanical Displacement to Electric Signal Transducer Technology (Sensor)			
	Electrostatic	Piezoelectric	Magneto-impedance
Pressure Sensor	✓	✓	
Accelerometer	✓	✓	✓
Microphone	✓	✓	
Gyroscope	✓	✓	
Magnetometer			✓

Electric Signal to Mechanical Displacement Transducer Technology (Actuator)			
	Electrostatic	Electromagnetic	Piezoelectric
Optical Switch	✓	✓	
Optical Scanner	✓	✓	✓

MEMS Piezoelectric Sensors and Actuators

The mechanical characteristics of a piezoelectric device are determined by the device structure and can be also evaluated electrically by measuring its oscillation modes, such as resonance and anti-resonance frequencies.

The impedance measurement method is the most accurate to evaluate the oscillation mode of piezoelectric device. The Agilent 4294A Precision Impedance Analyzer offers the highest class of impedance measurement accuracy as well as repeatability. It is the optimum tool for the evaluation and test of MEMS piezoelectric sensors and actuators. In addition, a wide variety of analysis functions can help designers increase their design productivity.

MEMS Magneto-Impedance Sensors

Evaluating the MI sensor's sensitivity is very important. Its sensitivity depends upon the impedance change of the amorphous magnetic material when a high frequency signal is applied.

The Agilent E4991A Impedance Analyzer is an ideal test instrument for characterizing MEMS MI sensors. This analyzer offers excellent accuracy and repeatability because of the advanced calibration function that removes instrument system measurement errors and residual impedance of the test fixture used. In addition, a wide variety of design-automation tools can help designers improve their design productivity.

MEMS Capacitive Sensors and Actuators

The capacitance of MEMS capacitive sensors and actuators needs to be measured as precise as sub-femto farad resolution because the capacitance change of the sensors and actuators is very small as its position changes very slightly. Accurate capacitance measurement requires an instrument with high measurement accuracy and repeatability.

The Agilent E4980A Precision LCR Meter, which provides high accuracy and repeatability as well as high-speed measurements, is the optimum measurement instrument for evaluation of MEMS capacitive sensor and actuator tests. Using up to 40-V DC bias function (Option 001) and 128-channel scanner interface (Option 301), this instrument can handle major tests of MEMS capacitive sensors and actuators.

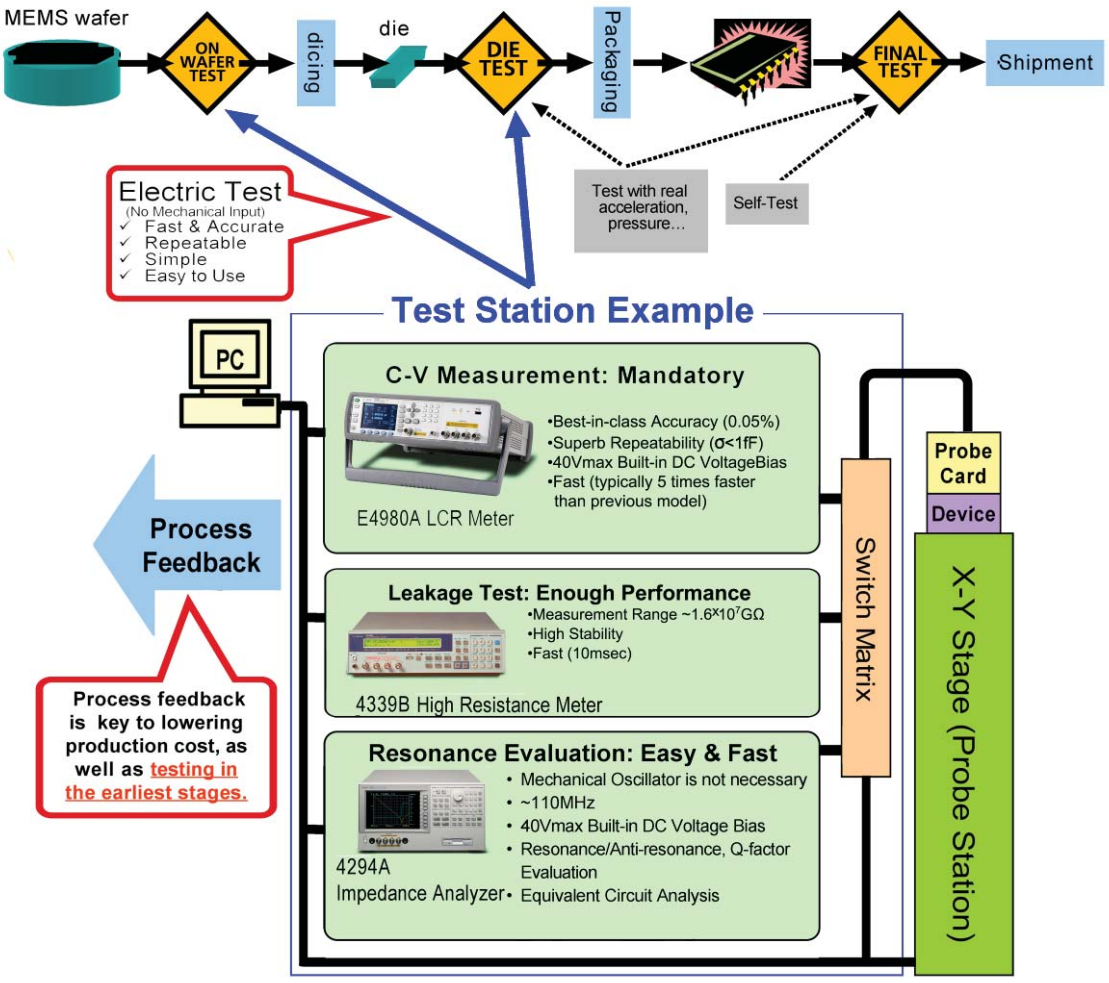
MEMS Electromagnetic Optical Switch/ Scanner

For MEMS optical switches and other devices, the electromagnetic actuator is often used as the actuator of the movable part. A micro coil and magnetic material operates the object. The basic principal of operation is the same as that of a mechanical relay.

The electrical characteristic of a coil can be obtained by measuring its impedance. As DC is used for the coil in a switch, inductance and DC resistance are the important parameters.

The Agilent E4980A Precision LCR Meter, which provides high accuracy and repeatability as well as high-speed measurement, is the optimum measurement instrument for the testing of a MEMS electromagnetic actuator. Using the DC parameter measurement function (Option 001) and 128-channel scanner interface (Option 301), the E4980A can handle the test demands of electromagnetic MEMS optical switch actuators.

Agilent Products and the MEMS Process

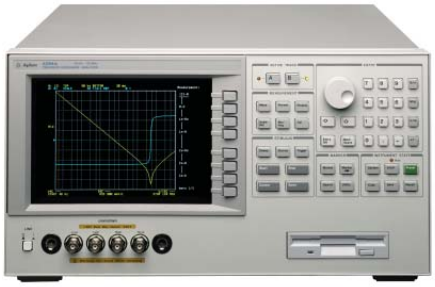


Summary

Agilent Technologies can deliver the right solution to accelerate your MEMS device development and manufacturing efficiency with our best-in-class impedance test instruments. Contact your Agilent sales representative or local office to help you to establish more accurate device modeling analysis and improve your test processes.

E4980A Precision LCR Meter

- C-V test for the capacitive sensor/actuator/microphone
- Inductance and DC resistance test for the electromagnetic actuator



4294A Precision Impedance Analyzer

- Test of the piezoelectric element in the piezoelectric type sensor/actuator
- Frequency response test of the silicon microphone
- Frequency response test for all sensor/actuator

4339B High Resistance Meter

- Leakage test for all devices

E4991A Impedance Analyzer

- Magneto-impedance test

More Information

More Information about Agilent's MEMS/NEMS device measurement solutions is available at the following website: w**ww.agilent.com/find/mems**

Agilent has also created the following series of Application Notes, available as pdf downloads:

- **Accurate Evaluation of MEMS Piezoelectric Sensor and Actuator using the 4294A** - Literature Number 5989-6516EN
- **Characterizing MEMS Magneto-Impedance Sensor using the Agilent Impedance Analyzer** - Literature Number 5989-6517EN
- **Improving the Test Efficiency of the MEMS Capacitive Sensor using the E4980A** - Literature Number 5989-6518EN
- **Characterizing Electromagnetic MEMS Optical Switch Actuator using the E4980A** - Literature Number 5989-6519EN
- **Characterizing Electromagnetic MEMS Optical Scanner using the E4980A** - Literature Number 5989-6520EN
- **Improving Test Efficiency of MEMS Electrostatic Actuator using the E4980A** - Literature Number 5989-6521EN

For additional product information, visit the following web sites:

- LCR and Resistance Meters: **www.agilent.com/find/lcrmeters**
- Impedance Analyzers: **www.agilent.com/find/impedance**

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Product specifications and descriptions in this document subject to change without notice.

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