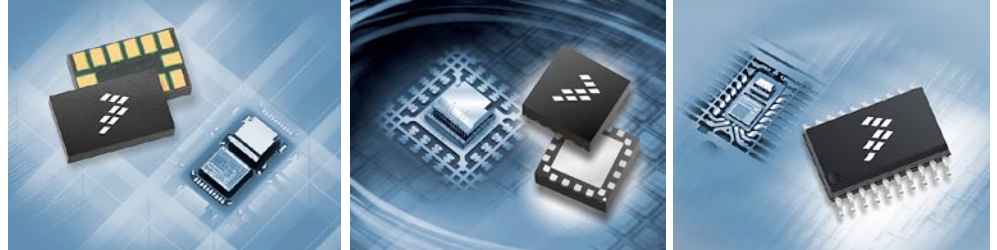# MEMS Technology

Overview

Micro-electromechanical systems (MEMS) are Freescale's enabling technology for acceleration and pressure sensors. MEMS-based sensor products provide an interface that can sense, process and/or control the surrounding environment.

Freescale's MEMS-based sensors are a class of devices that builds very small electrical and mechanical components on a single chip. MEMS-based sensors are a crucial component in automotive electronics, medical equipment, hard disk drives, computer peripherals, wireless devices and smart portable electronics such as cell phones and PDAs.

HARMEMS Technology

Freescale's next-generation high aspect ratio micro-electromechanical systems (HARMEMS) is a proven technology for airbag sensing applications. The accelerometers have an advanced transducer design that enhances sensor offset performance. HARMEMS technology provides over-damped mechanical response and exceptional signal-to-noise ratio to address customer requirements.

Since the airbag main ECU system is installed in the vehicle cabin, over-damped HARMEMS technology enables a high degree of immunity to high-frequency, high-amplitude parasitic vibrations. HARMEMS technology has also been introduced in dual-axis accelerometers used in electronic stability control (ESC) to measure the lateral acceleration of the vehicle.

Target Applications

For automotive safety, acceleration sensors provide crash detection for efficient deployment of forward and side airbags as well as other automotive safety devices. Accelerometers are also used in electronic stability control (ESC) to measure the lateral acceleration of the vehicle to help drivers maintain control of their vehicles during potentially unstable driving conditions. Acceleration sensors are also part of Freescale's tire pressure monitoring system (TPMS) to detect whether the car is moving to save power, wheel speed and/or direction of rotation.

In specialized health care monitoring applications, pressure sensors provide key patient diagnostics for patients. In cell phones, MEMS products activate different features by using more natural hand movements of tilting rather than pushing several buttons.

Freescale Semiconductor has been developing MEMS-based sensors for almost 30 years. The process technology used to manufacture the sensors can broadly be grouped into bulk micromachining and surface micromachining.
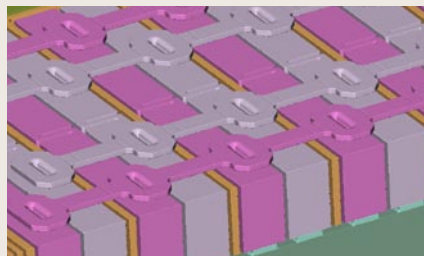
Technology Comparison

Poly-Si MEMS Technology

Finger cross section with slight squeeze film damping

Movable

3 um

Fixed   Fixed
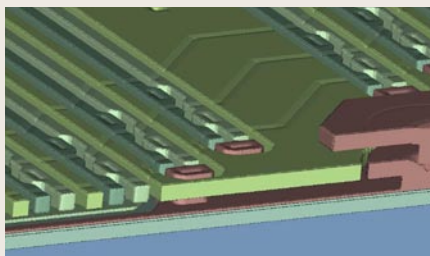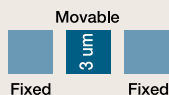
HARMEMS Technology

Finger cross section with squeeze film damping

Movable

25 um

Fixed   Fixed
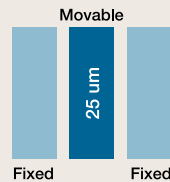
HARMEMS technology has a 25 um movable element thickness designed to attenuate sensor resonant frequency for robust accuracy in automotive safety applications

freescale™
semiconductor

Level I	Level II	Level III	Level IV	Level V
Discrete Devices	Basic Integration	Mixing Technologies	Selection Integration	Full Integration

Bipolar Sensor · Bipolar Sensor · MCS Compatible Sensor · Multi-Chip Sensor Controller · Discrete Sensor Interface · Integrated Sensor Interface · "Smart" Sensor · HCMOS MCU · HCMOS MCU · MCU + LDMOS + Interface · MCU + High Current High Voltage Drivers · Fully Integrated Sensor System · MOS Driver · MOS Driver · SMARTMOS™ Drivers

Freescale continues to leverage technology expertise in micromachining to provide more integration in embedded solutions

Technology Benefits

Freescale's MEMS technology provides the following advantages: cost efficiency, low power, miniaturization, high performance and integration. Functionality can be integrated on the same silicon or in the same package, which reduces the component count and contributes to overall cost savings.

The two variations of integrated microsystems include monolithic integration and system-in-a-package. Monolithic integration involves the inclusion of the MEMS device and the integrated circuit on the same piece of silicon. System-in-a-package includes the MEMS device and the integrated circuit in the same package.

Bulk Micromachining

In bulk micromachining, the single crystal silicon is etched to form three-dimensional MEMS devices. This is a subtractive process in which the silicon in the wafer is specifically removed using anisotropic chemistries. Using this bulk micromachining method, sensors such as piezoresistive pressure sensors have

been manufactured in high volume. Devices are formed with single crystal silicon, which is a very stable mechanical material.

In the simplest implementation, the silicon is selectively etched in certain areas to form a diaphragm. In an absolute pressure sensor, the silicon wafer is then bonded with another wafer (either of silicon or glass) to form a vacuum-sealed cavity below the diaphragm. The diaphragm then deflects in response to the applied pressure.

The transduction mechanism that has been widely used is the piezoresistive effect. In piezoresistive materials, the change in the stress causes a strain and a corresponding change in the resistance. Thus, when implanted piezoresistors are formed at the maximum stress points of the diaphragm, the deflection under the applied pressure causes a change in the resistance. Typically, these piezoresistors are formed as a bridge network and the voltage applied between two terminals causes an output voltage to be measured between the other two terminals.

Surface Micromachining

In surface micromachining, the MEMS sensors are formed on top of the wafer using deposited thin film materials. These deposited materials consist of structural materials that are used in the formation of the sensor device. Sacrificial layers are deposited and then removed to form the mechanical spaces or gaps between the structural layers.

Many of the surface micromachined sensors use the capacitive transduction method to convert the input mechanical signal to the equivalent electrical signal.

In the capacitive transduction method, the sensor can be considered a mechanical capacitor in which one of the plates moves with respect to the applied physical stimulus. This changes the gap between the two electrodes with a corresponding change in the capacitance. This change in capacitance is the electrical equivalent of the input mechanical stimulus.

Freescale's TPMS integrates a surface micromachined, capacitive pressure sensor (middle exposed package), an 8-bit MCU, an RF transmitter and an XY-axis accelerometer (left exposed package) all in a single SOIC.
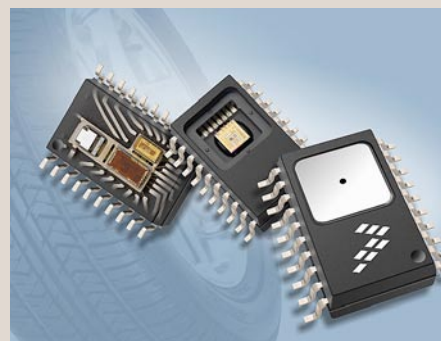
Learn More: For more information about Freescale products, please visit **www.freescale.com/sensors.**

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