measurement SPECIALTIES

MEAS Silicon MEMS Piezoresistive Accelerometer and its Benefits

Embedded Sensing Technologies

Piezoresistive Accelerometers

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1. Bonded Strain Gage type

    (Gages bonded to metal seismic mass using epoxy)

    - Undamped circa 1950's
    - Fluid (oil) damped circa 1960's

2. Silicon MEMS type

    (Gages defused into single piece of silicon)

    - Undamped circa 1980's
    - Gas damped circa 1990's

Piezoresistive Accelerometers

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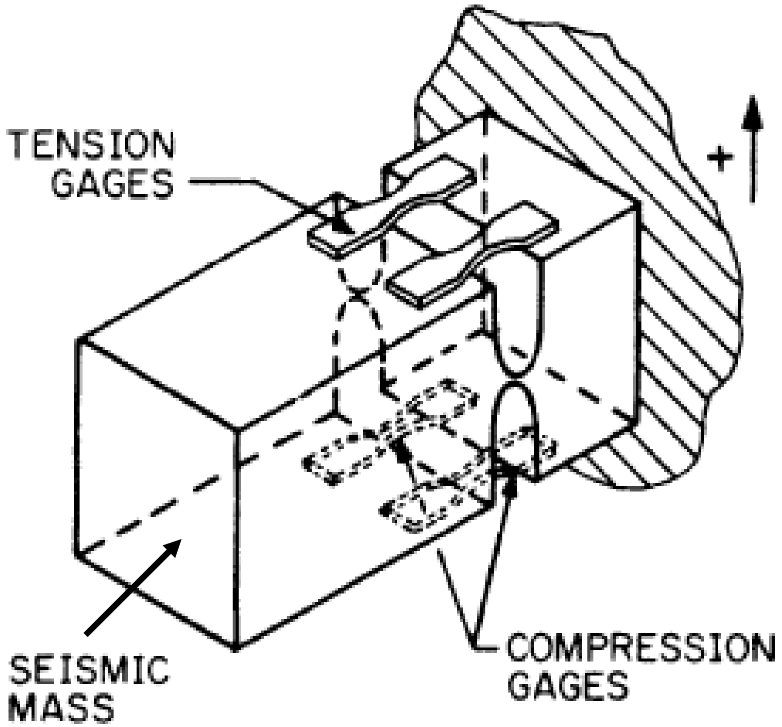
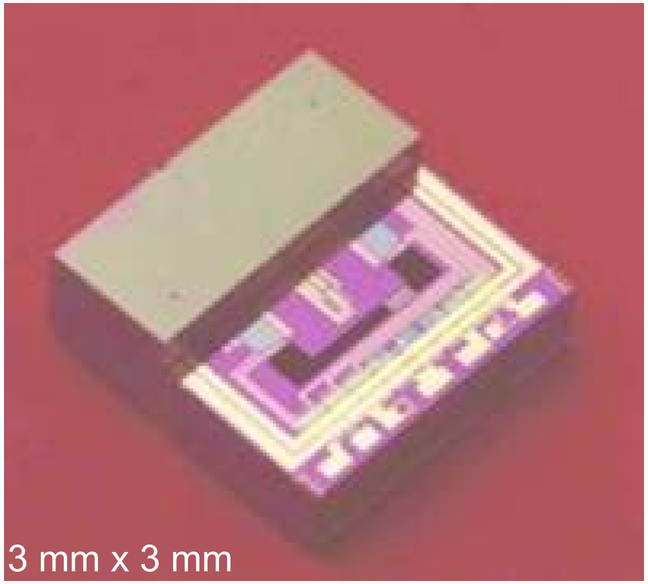


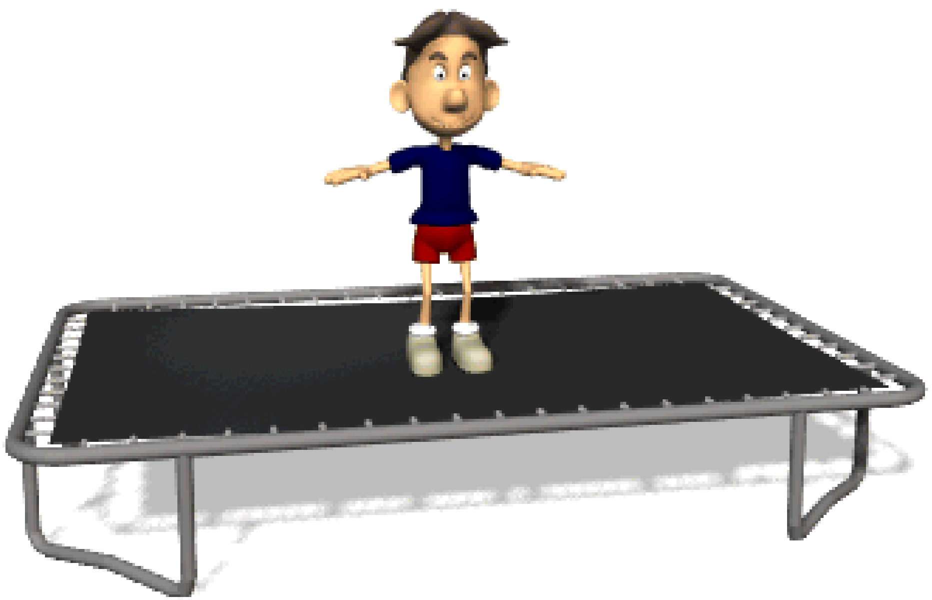
Typical Bonded Strain Gage Sub-Assembly



MEAS Silicon MEMS Element

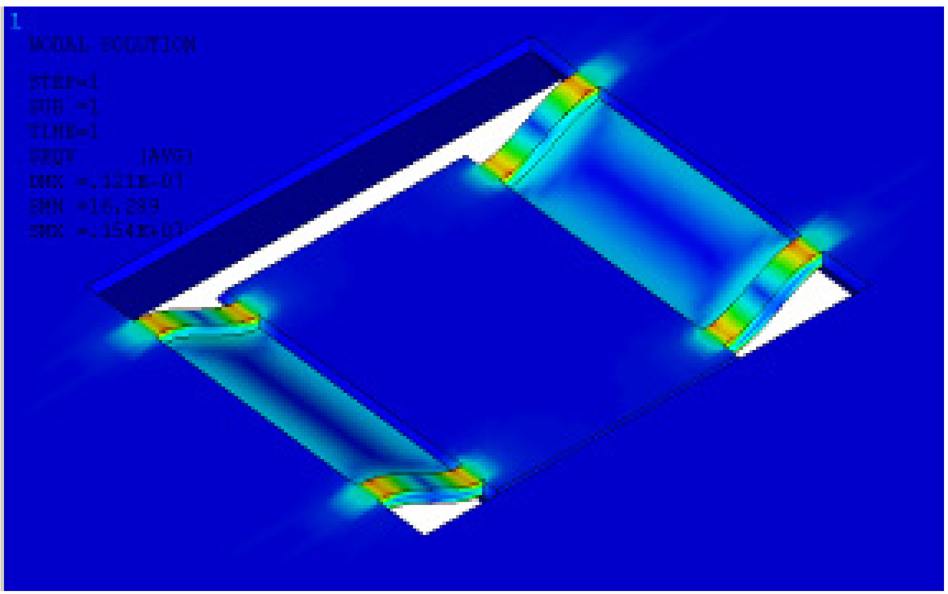
How Silicon MEMS Accelerometers Work

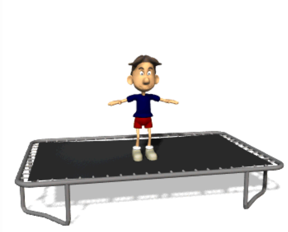
MEMS = Micro Electro Mechanical Systems

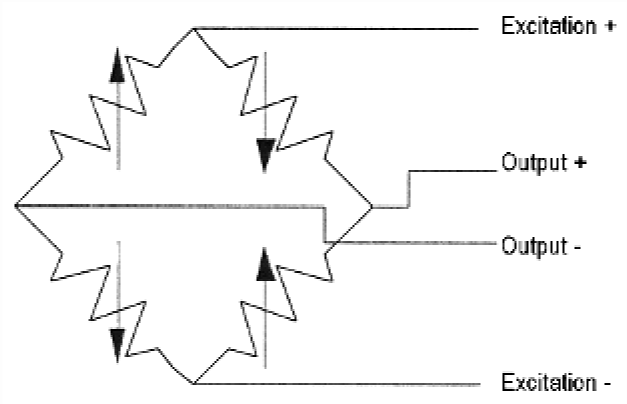


Works Like a Trampoline

Silicon MEMS Construction:



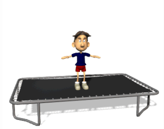


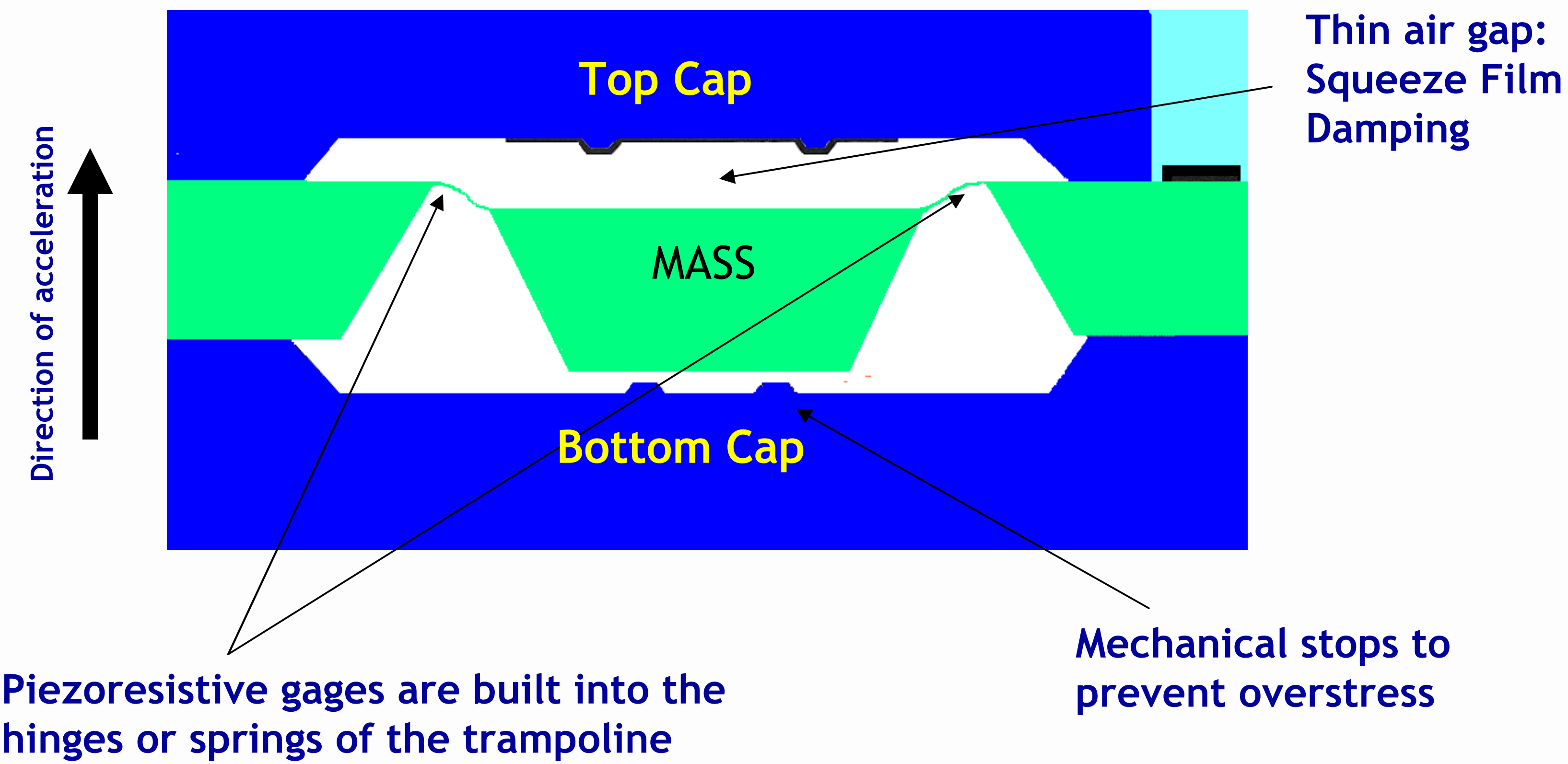


Piezoresistive gages sense changes in stress and strain in the hinges (springs in the trampoline) under acceleration

The four springs are wired in a 4-arm Wheatstone Bridge configuration

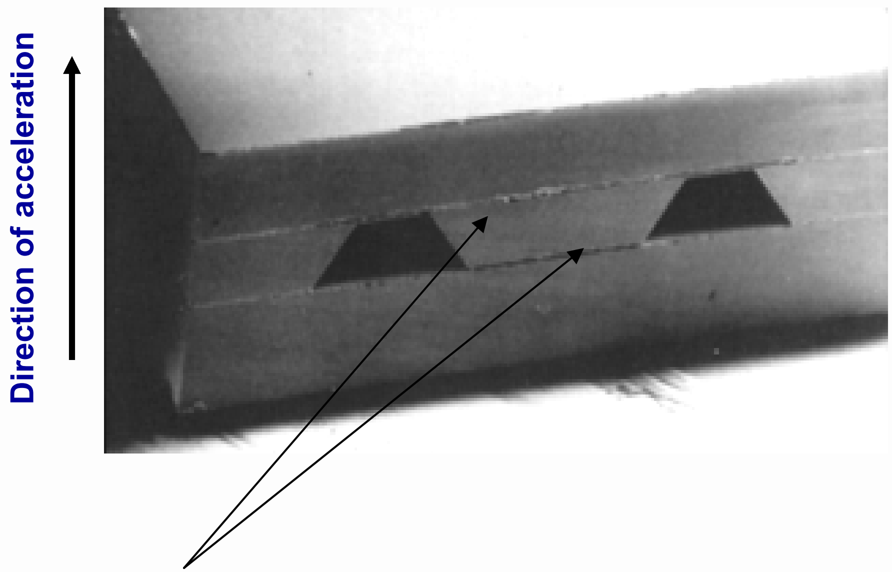
Silicon MEMS Construction, Cross-sectional View



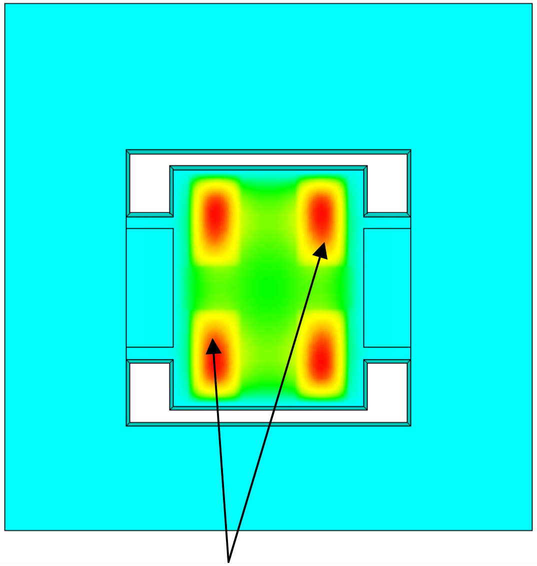


Squeeze-Film Gas Damping

cross sectional view



top view

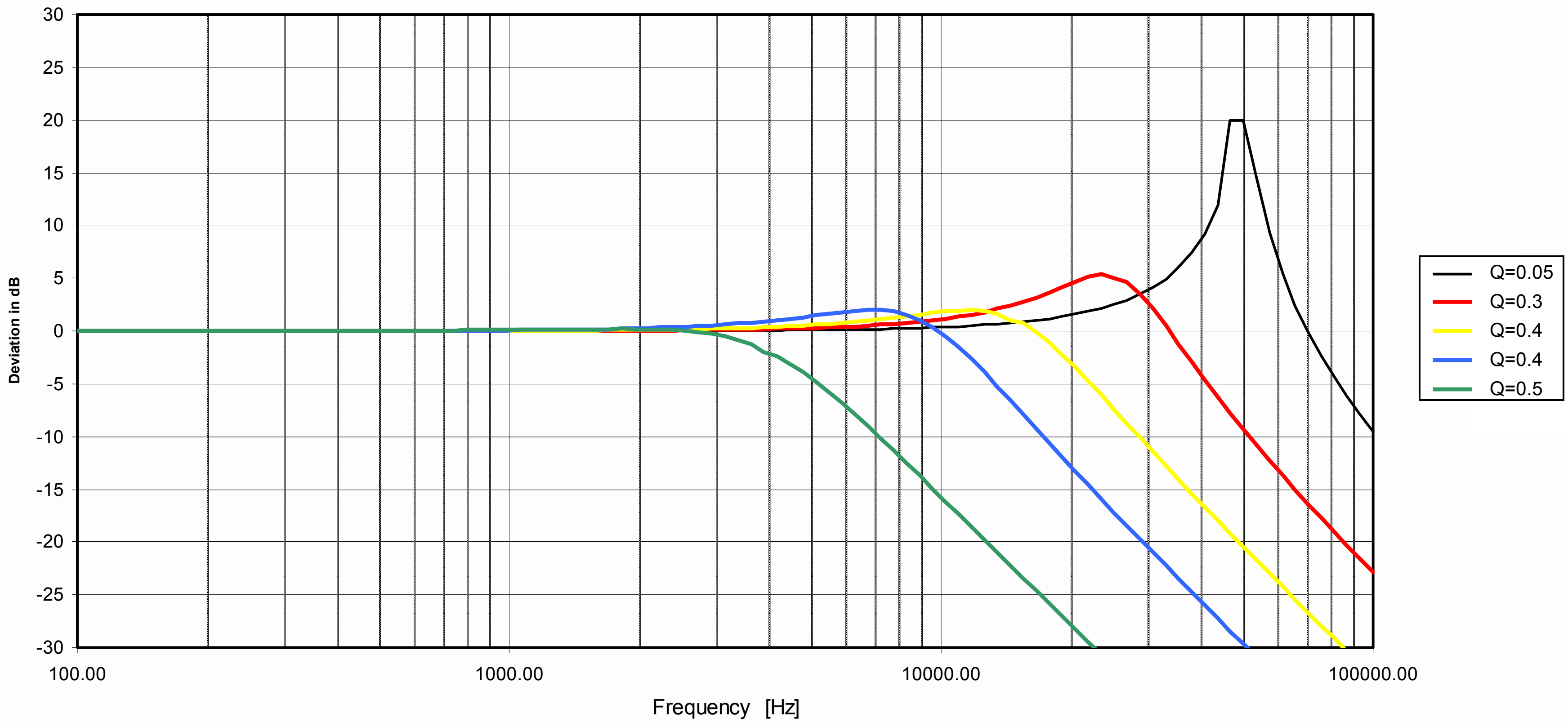


Extremely small airgaps between the moving seismic mass (in the middle) and the top/bottom caps facilitate squeeze film damping.

Damping is obtained from the integrated pressure profile at the surface of the sensor cell. Airgap thickness controls the effective damping ratio of the device.

Silicon MEMS Accelerometers

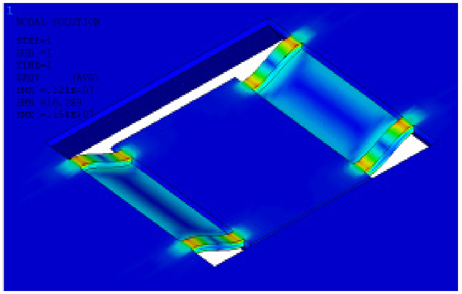
Typical Damping Ratios Using Squeeze-Film Technique

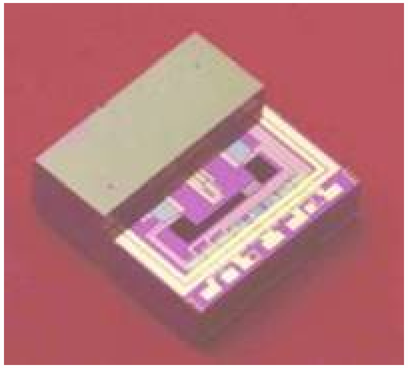


What are the Benefits?

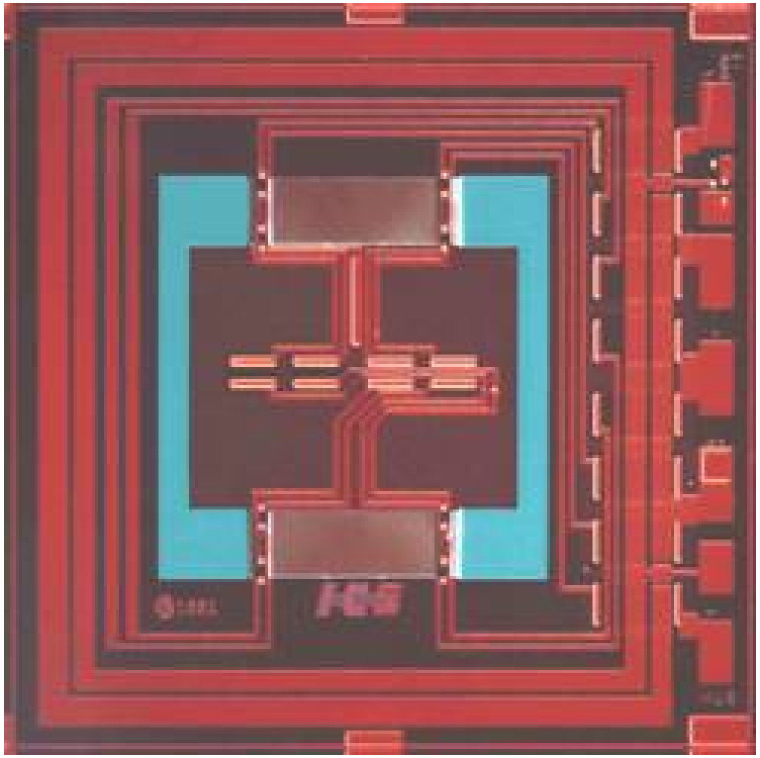
Benefit: Low Off-Axis Sensitivity

Patented double-cantilever webbed design provides low off-axis sensitivity with minimum response to cross and rotation acceleration commonly found in dynamic testing.





Silicon MEMS sensor element



Sensor design with high rotational & translational stiffness

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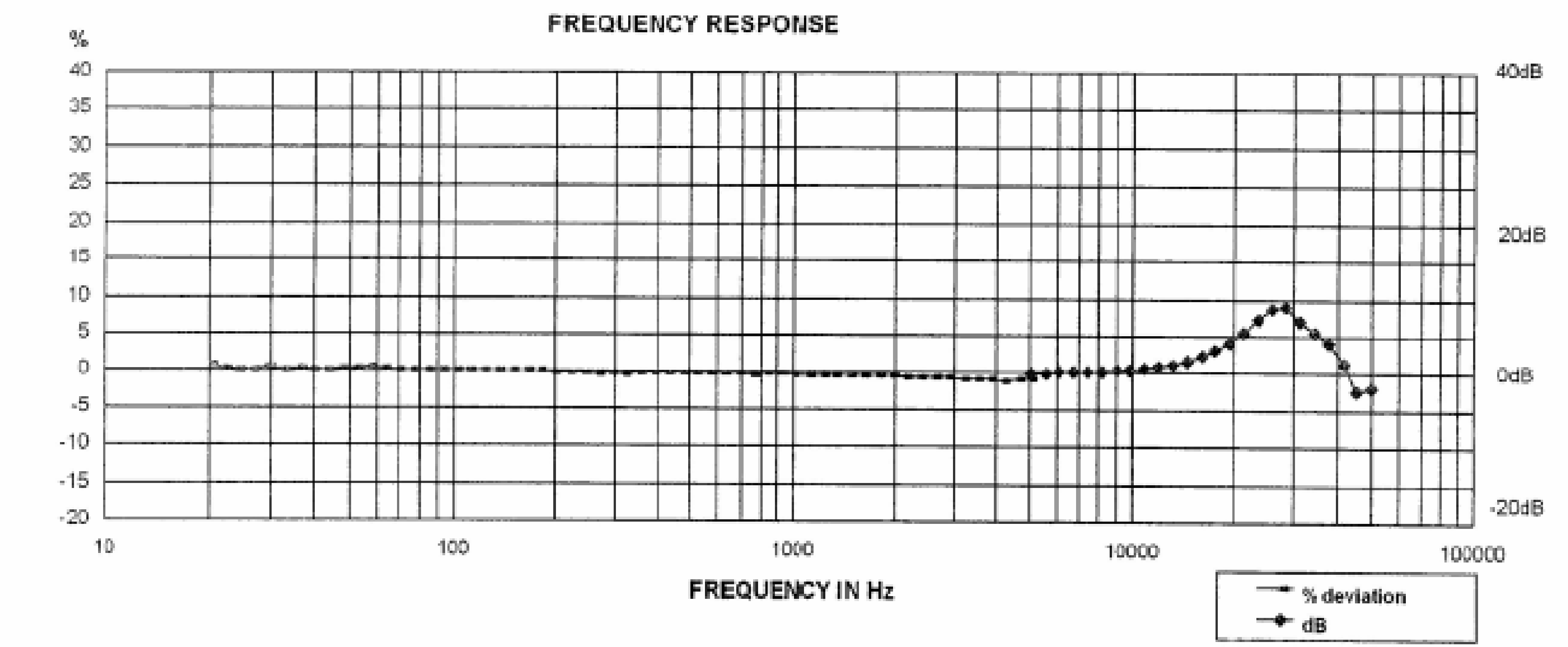
Benefit: Resonance Control & Broad Response

MEAS's MEMS accelerometers offers the optimal amount of damping to achieve maximum resonance control when the sensor is exposed shock impact, and still maintains the broadest frequency response required by the various industry regulations, such as SAE-J211 and ISO-6487.



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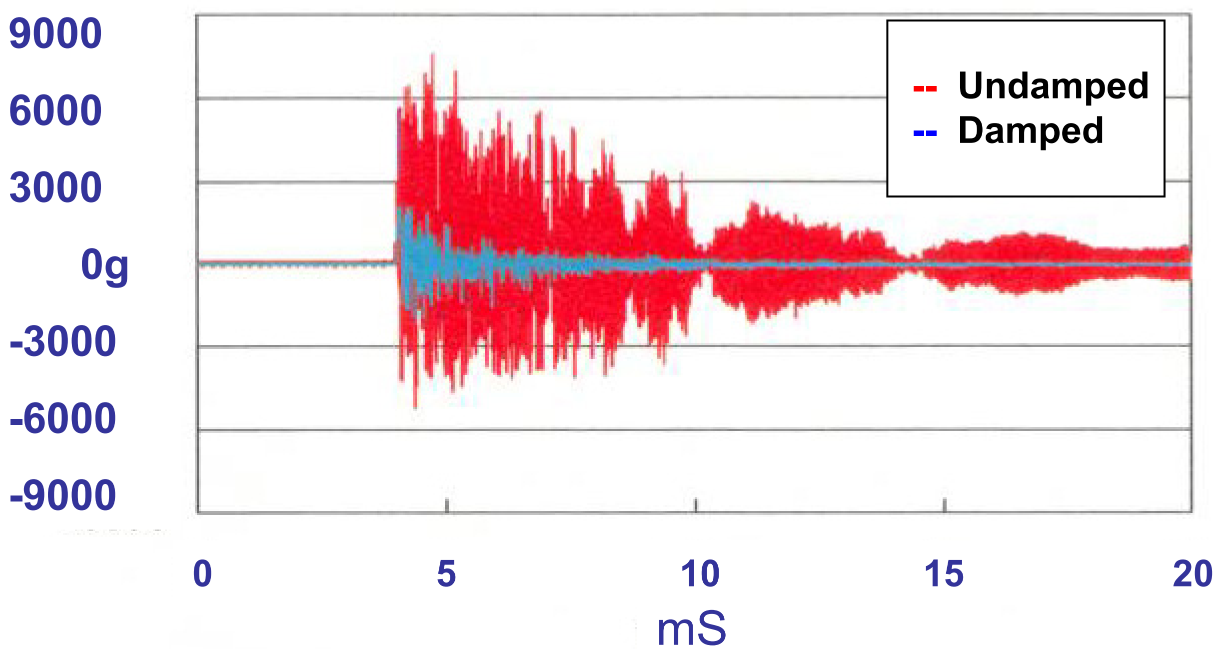
Example of Resonance Control in Damped Accelerometer

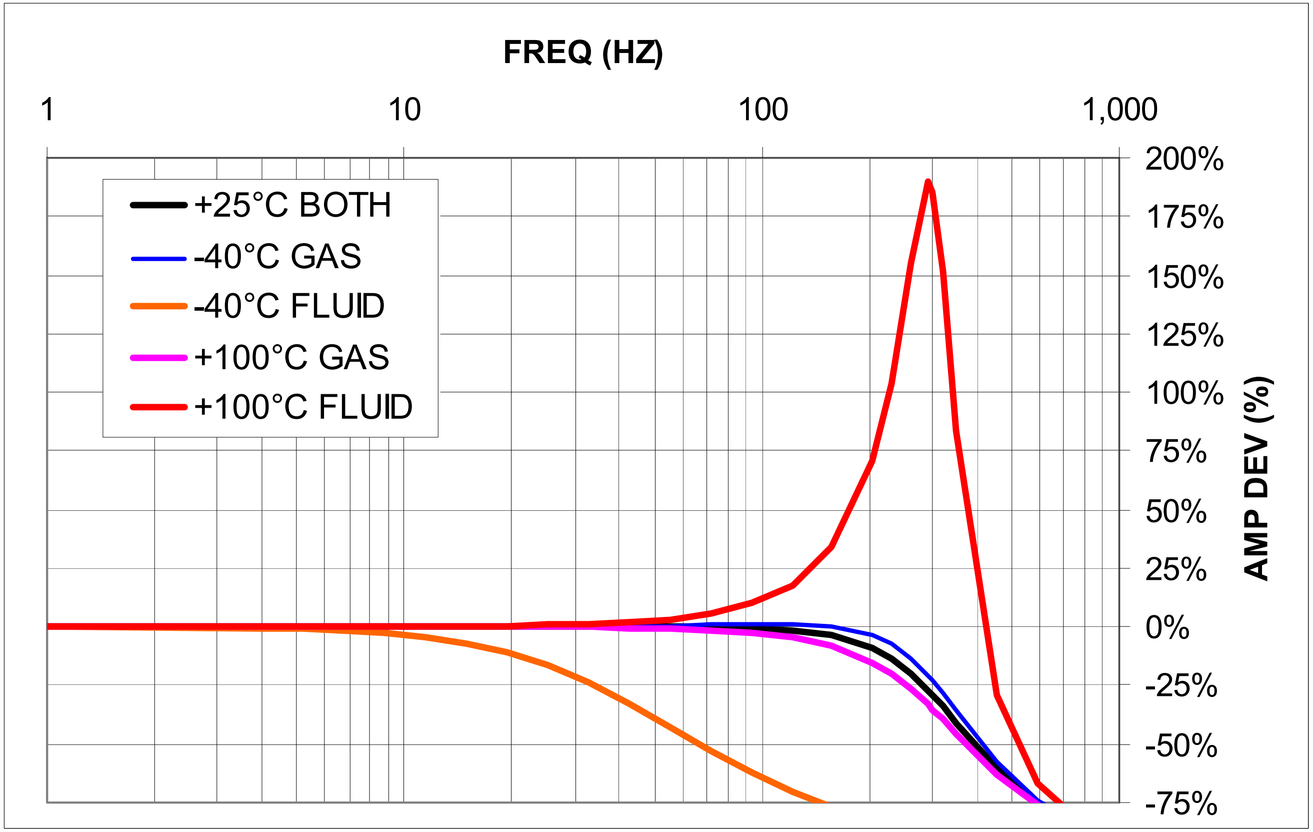


Undamped accelerometer resonated at its natural frequency after exposed to shock impulses

MEAS' MEMS Advantages

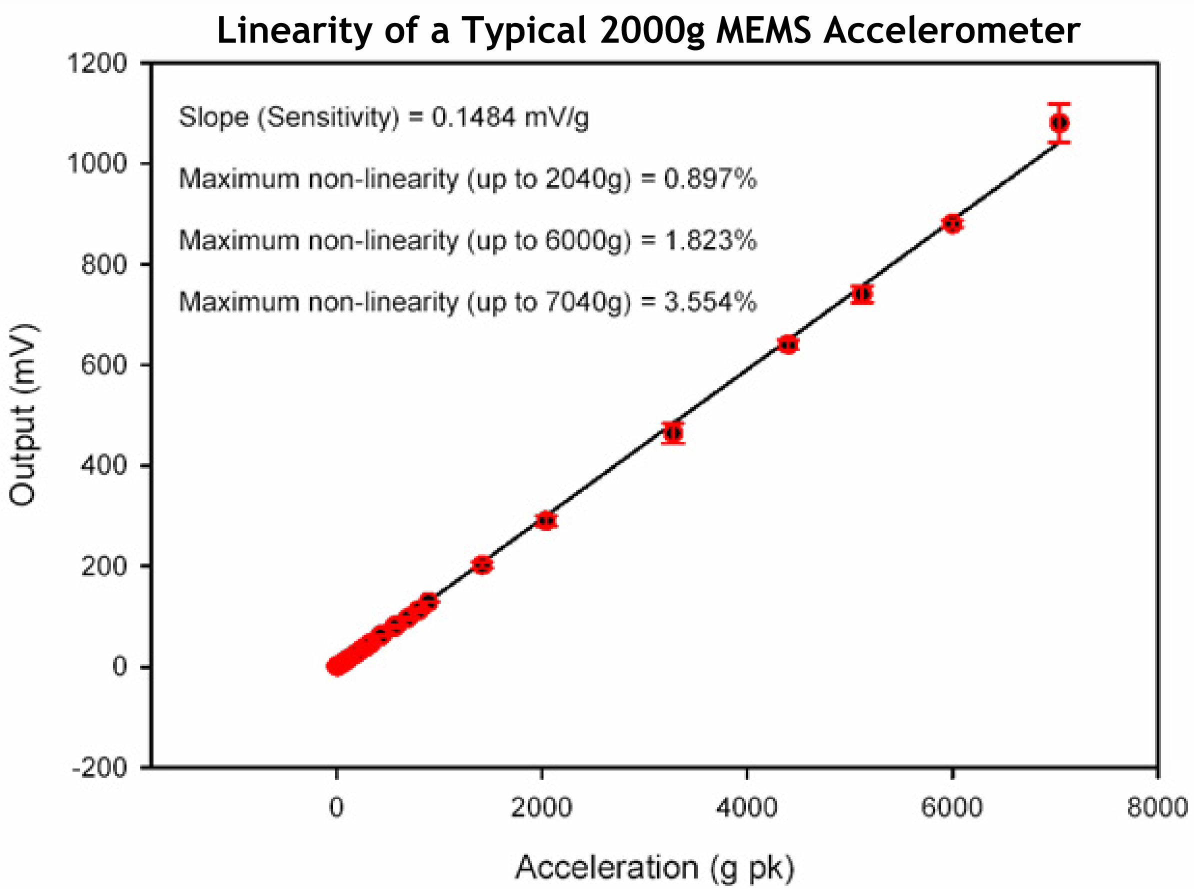
Benefit: Stable Response over Temperature

Compared to a fluid damped design in which damping characteristics changes dramatically with fluid viscosity at various temperature, frequency response of MEAS's gas damped accelerometer is not affected by temperature.



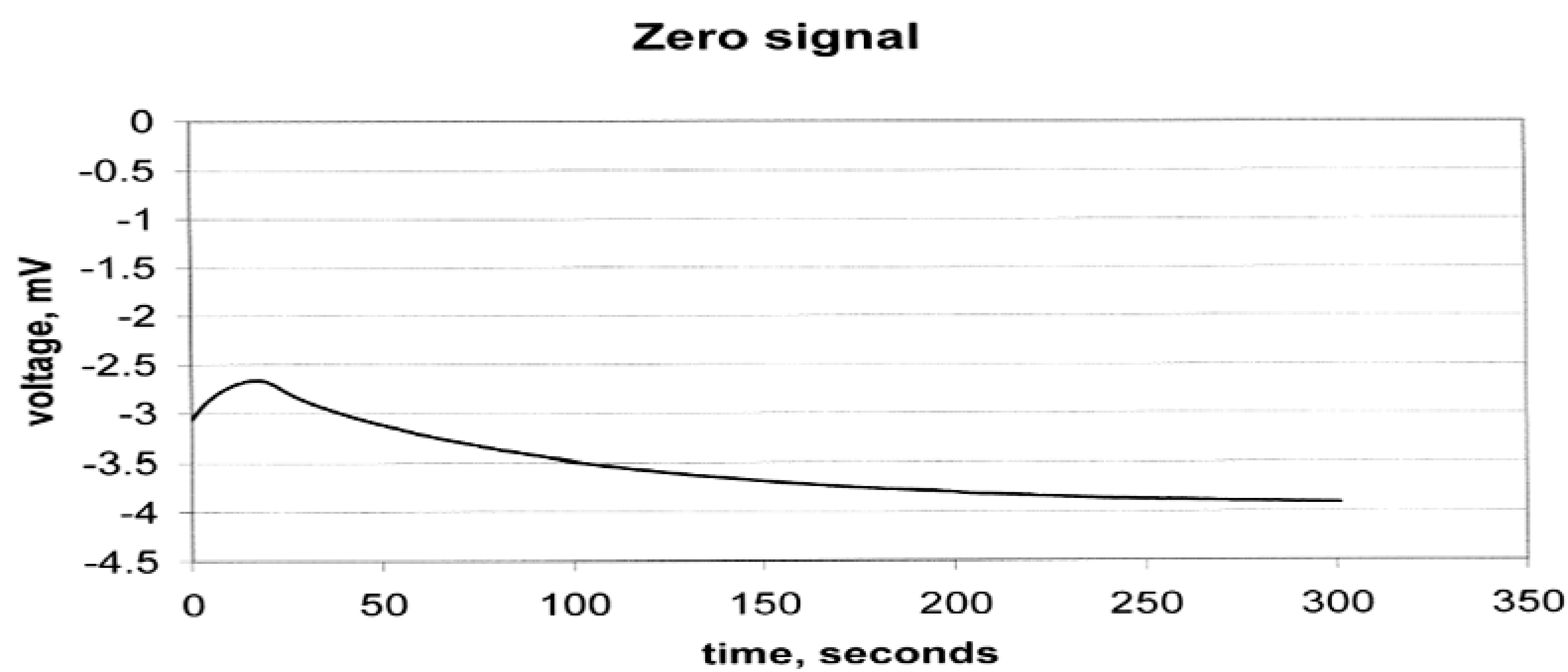
Benefit: Excellent Dynamic Range and Linearity

Compared to capacitive designs, MEAS's silicon MEMS piezoresistive accelerometers offer much broader mesurement range and unmatched amplitude linearity.



Benefit: Shorter Warm-Up Time

After power is applied to the sensor, the zero offset of the accelerometer stabilizes as the heat generated by the gages reaches an equilibrium. In a MEAS design, the thermal imbalance in the full bridge configuration is kept to a minimum due to the uniform heating in all 4 active silicon gages. Competitor's design using half-bridge configuration (2 active gages and 2 completion resistors) produces thermal imbalance due to uneven the heating characteristics that take much longer to reache an equilibrium.



MEAS' MEMS Advantages

Benefit: Better Thermal Stability

With higher gage impedance, MEAS's design comsumes considerably less power than competitor's sensor, hence lower heat dissipation. Lower heat dissipation translates into higher thermal stability and faster warm-up time.