Semiconductor Technology from A to Z

Micromechanics

The MEMS Accelerometer

Structure: Seismic Mass and Springs

A MEMS accelerometer measures acceleration by exploiting the inertia of a small, movable mass – the so-called seismic mass, or proof mass. This mass is connected to the surrounding, fixed substrate via thin, elastic spring structures, usually fabricated using surface micromachining from the same polysilicon structural layer as the mass itself. When acceleration acts on the sensor, the mass initially lags behind due to its inertia while the housing moves along with it – the springs deflect the mass relative to the substrate, proportional to the acceleration acting on it.

The deflection itself is typically tiny – often just a few nanometers to a few micrometers – which is why it is read out electrically rather than mechanically.

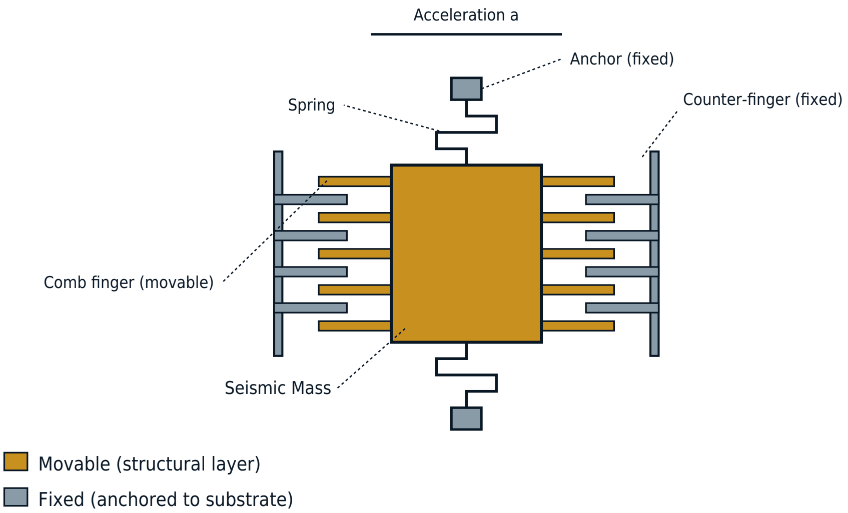
Capacitive Readout: The Comb Structure

For electrical readout, the seismic mass carries fine, comb-like interdigitated fingers along its edges, which together with fixed counter-fingers on the substrate form an array of small capacitors – hence the name comb structure (or comb-drive). Each movable finger forms two capacitors with its two neighboring fixed fingers, whose capacitance depends on the spacing between the fingers.

When the mass moves due to an applied acceleration, the spacing decreases on one side of each finger pair and increases on the other – one capacitance rises while the other falls. This opposing (differential) change in capacitance can be measured precisely and largely independently of temperature fluctuations, since disturbances typically affect both capacitances equally and cancel out when the difference is taken.

The Comb Structure of a MEMS Accelerometer

Top view: seismic mass, springs and comb fingers



As the mass moves, the finger spacing changes in opposite directions – one capacitance rises while the other falls (differential measurement).

From Capacitance Change to Signal

A readout circuit (ASIC) integrated directly next to the mechanical structure converts the tiny differential capacitance change – often in the femtofarad range – into a measurable voltage. This close spatial proximity of the mechanical sensor element and the electronics is one of the main reasons accelerometers are typically fabricated using surface micromachining: both parts can be realized on the same chip, or at least in the same package, with short signal paths.

In addition, the spring-suspended mass is often lightly damped, for example by the surrounding gas in the package, to prevent uncontrolled ringing after abrupt changes in acceleration and to set the sensor's usable bandwidth.