Semiconductor Technology from A to Z

Micromechanics

The Microphone and Pressure Sensor

Shared Principle: Membrane Over a Cavity

Both the MEMS microphone and the MEMS pressure sensor rely on the same basic principle: a thin, elastic membrane stretched over a sealed or backside-open cavity that deflects under applied pressure. The membrane itself is usually fabricated using bulk micromachining – by etching the substrate from the back down to a thin remaining layer, as described in the chapter on bulk vs. surface micromachining.

The key difference between a microphone and a pressure sensor lies less in the mechanical structure than in the readout method and the magnitude of the pressure changes to be captured: a microphone measures fast, tiny sound-pressure fluctuations in the range of a few pascals, while a pressure sensor typically measures slower, larger pressure changes up to several bar.

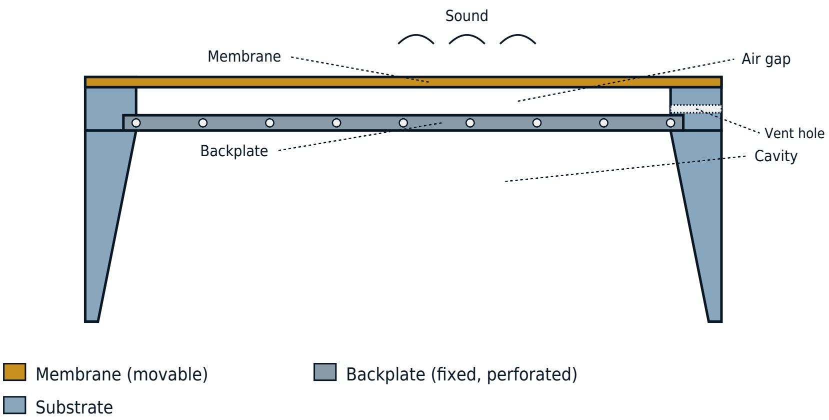
The MEMS Microphone: Membrane and Backplate

In the capacitive MEMS microphone, today's most common design, the movable membrane faces a perforated, fixed backplate riddled with countless small holes so that air can pass through almost unimpeded. Membrane and backplate together form a capacitor: when sound hits the membrane, its distance to the backplate changes in step with the sound wave, and the capacitance fluctuates accordingly.

A readout circuit converts this tiny capacitance change into an electrical signal, similar to the comb structure of the accelerometer – except that here a parallel-plate configuration is used instead of a comb configuration. A small vent hole equalizes slow air-pressure fluctuations (from weather or altitude changes, for example) without affecting the fast acoustic signals.

The MEMS Microphone in Cross-Section

Membrane, air gap and perforated backplate



Sound deflects the membrane, changing its distance to the backplate – the capacitance between them fluctuates in step with the sound wave.

The MEMS Pressure Sensor: Piezoresistive Readout

The classic MEMS pressure sensor usually uses a different readout method: four piezoresistive resistors are placed on the membrane so that their electrical resistance changes as the membrane deflects – at locations of maximum mechanical stress, usually near the edge of the membrane. The four resistors are wired into a Wheatstone bridge, a circuit topology that converts small, opposing resistance changes into a precisely measurable output voltage.

Depending on whether the cavity beneath the membrane is evacuated, filled with a reference pressure, or open to the environment, the sensor measures absolute, gauge, or differential pressure. Applications range from tire-pressure monitoring systems to barometric altitude sensing in smartphones to medical ventilators.