MEMS Microphones

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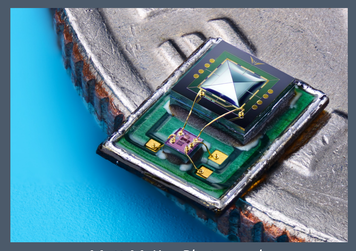
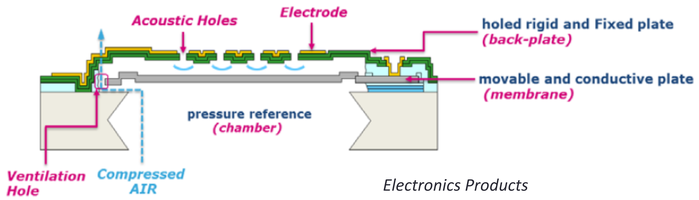
Micro
Electro
Mechanical
Systems



Matt McKee Photography

Introduction

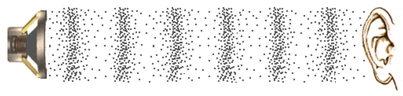
- MEMS (**Micro-Electro-Mechanical-System**) devices are extremely small machines and sensors that each of us utilize on a daily basis. Microphones are among the most common types of MEMS, as they are a crucial component in all modern computers, phones, cars, headphones, and hearing aids.
- The diagram below shows a cross-section of a MEMS condenser microphone.



Electronics Products

Background: Sound

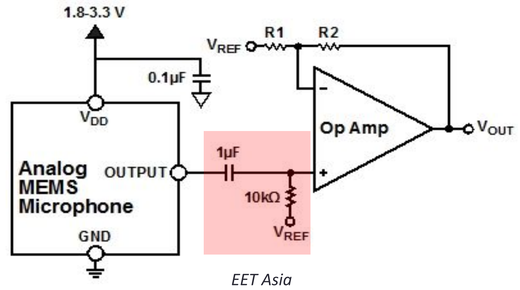
- Sound waves are made up of areas of compression and rarefaction of air particles. This is why sound needs a medium to travel through.
- The purpose of a microphone is to capture these waves of pressure, and convert their energy into an electrical signal.



Media Collage

Microphone Circuitry

- There are two main issues related to microphones that can be solved using circuitry. An example of a MEMS microphone circuit diagram is shown below.
- First, the output signal produced by a microphone will often be noisy, and there will be only a specific range of frequencies that need to be isolated. This is achieved with electrical filtering. Highlighted in red in the microphone circuit is a **high pass filter** that will not allow frequencies below the range of human hearing to pass through.

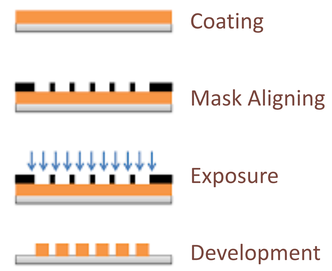


EET Asia

- The signal produced by microphones is often very small, and needs to be amplified for most uses. This is often achieved using an **operational amplifier**, show on the right of this circuit diagram, in a **negative feedback** configuration. Resistors **R1 and R2** form a voltage divider that tunes the gain of the amplifier.

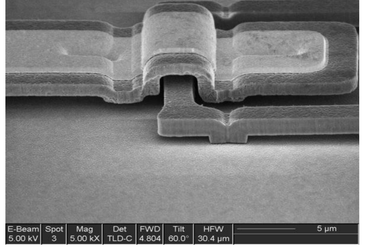
Fabrication

- MEMS are fabricated through a **photolithography** process, outlined in the four steps to the right. First, a silicon wafer is coated with a layer of photoresist (material that is sensitive to UV light). UV light is then shone through a glass mask with a pattern printed on it. Finally, the wafer is bathed in a solvent so the areas that were exposed to the light will dissolve away, leaving a pattern on the wafer.



InTech Open Minds

- This process is repeated anywhere from 10's to 100's of times to make complicated geometries.
- One wafer holds thousands of MEMS parts which are all fabricated simultaneously.
- (Right) A MEMS hinge at the scale of 5µm, fabricated using this lithography process

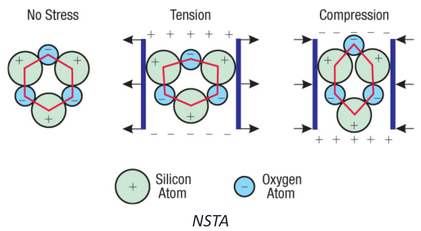


Fiber Optics For Sale

Types of Microphones

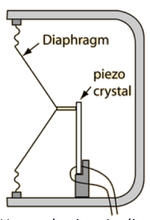
Piezoelectric

- Piezoelectric materials are crystals that generate an electric potential in response to mechanical stress, shown to the right using a 2D depiction of Quartz (SiO_2).



NSTA

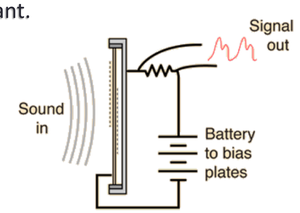
- In a piezoelectric microphone, a thin piece of piezoelectric material is attached to a diaphragm which vibrates with incoming sound waves.
- The resulting compression and tension in the crystal causes alternating polarizations which mirror the incoming waves of pressure.



Hyperphysics: Audio

Condenser

- Condenser microphones are also known as capacitor microphones because they use a charged diaphragm and back-plate to form a **variable capacitor.**
- In the diagram of a condenser microphone shown below, the power source will hold the voltage across the capacitor constant.
- If the distance between the plates of the capacitor changes due to the incoming sound waves, the charge on the plates will have to change, meaning current will have to flow through the circuit. This change will follow the equation relating the voltage across the capacitor to its geometry.
- These changes in current will be readable as the voltage across the resistor in the circuit, because of Ohm's law, **V=IR**



Hyperphysics: Microphones

$$V = \frac{Qd}{\varepsilon_0 A}$$

Sources

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