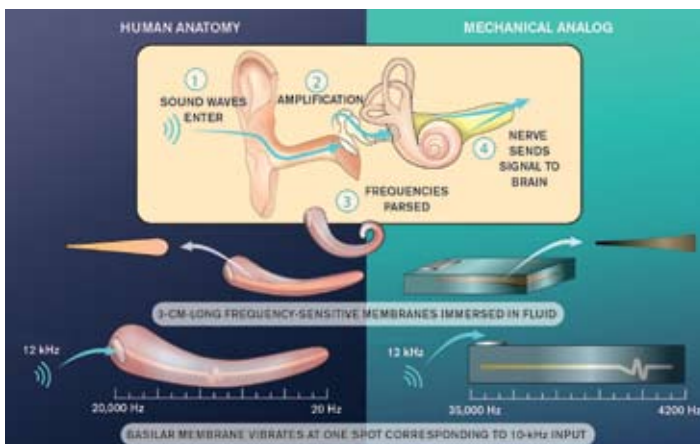


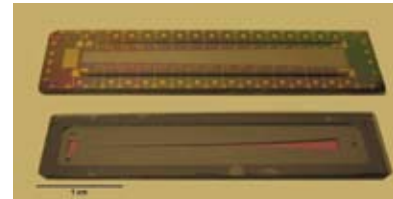
- + Read an expanded version of this article at [www.edn.com/081002prv](http://www.edn.com/081002prv).
- + Go to [www.edn.com/pryingeyes](http://www.edn.com/pryingeyes) for past Prying Eyes write-ups.

## Artificial cochlea: an example of structural processing

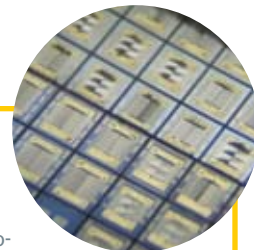
The cochlea is the portion of the inner ear that senses sound vibrations and converts them into electrical signals that the auditory system can interpret. The cochlea is an example of active cellular mechanical forcing and structural processing in which the shape and physical composition of the sensory organ work in combination to accomplish a complex transform. In this case, the cochlea separates a sensed, complex sound wave into its basic frequency components.



The cochlea is a curled structure, which is filled with fluid that moves in response to the vibrations coming through the oval window from the middle ear. Along the length of the cochlea are thousands of hairs that are set in motion in the liquid at the resonance points of the incoming sound wave. Each hair, based on its position within the cochlea, essentially isolates and detects a frequency band. This task is much like performing an FFT (fast Fourier transform) on a sound wave received on a conventional microphone but without performing the digital computations of the FFT (courtesy Zina Deretsky, National Science Foundation).



Current state-of-the-art technology for an artificial cochlea operates in a similar fashion except that, unlike the tightly curled cochlea, the MEMS (microelectromechanical-system)-based cochlea stretches out in a linear structure. The 3-cm-long device comprises an acoustic input port at the narrow end of a tapered strip. Where the strip is narrow, the sense material is stiff and vibrates in response to high-frequency compression waves in the fluid that the strip is immersed in. Additionally, as the strip widens, the material is more compliant, vibrates more easily, and absorbs the energy of lower-frequency waves (courtesy Karl Grosh, University of Michigan, and Robert White, Tufts University).



Earlier versions of the micromechanical cochlea used a capacitive-sensing approach, but the development team is working with piezoelectric sensing that takes better advantage of lithography and etching techniques. Although the structure of the cochlea passively separates a sound wave into its components' resonance points, the act of sensing the resonance points and converting them into a usable signal is an active process. The current implementation of the artificial cochlea relies on a cantilever-beam structure in which each beam is supported on only one end and the free end of the beam can sense motion of the micromechanical cochlea. This image shows sets of cantilevers that could be used for this purpose and integrated directly into the fabrication of the artificial cochlea. The pictured devices were fabricated to make many thousands of piezoelectric MEMS microphones. This technology was co-opted for the purpose of a cochlear sensor (courtesy Karl Grosh, University of Michigan).