Sound Reveals a Hidden Microscopic World

A new acoustic microscope possesses the clarity of optical devices but can probe features beneath a surface

BY JOHN H. DOUGLAS

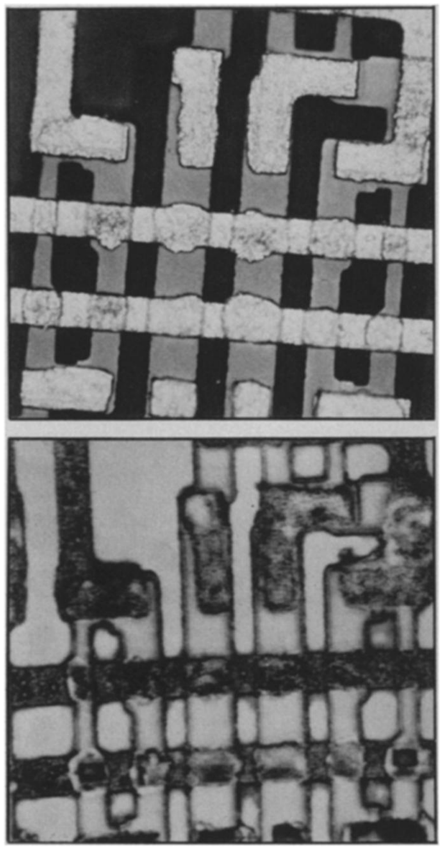
Nature at large bombards the senses, but even a glimpse of the microscopic world requires the subtlest discrimination. Reflecting from tiny contours, an electron beam can reveal a gnat's eye as a surrealistic landscape of geometric patterns, but it gives no hint at what lurks just beneath. An optical microscope transforms a living cell into a collage of psychedelic colors, but the internal properties of light conduction tell little about why some cancer cells metastasize. Now, extremely high frequency sound may enable scientists to explore these and other hidden features of microscopic subjects ranging from integrated circuits to blood cells.

An acoustic microscope that can see into a material as clearly as an optical microscope examines its surface has been developed at Stanford University by professor Calvin F. Quate and graduate student Victor Jipson of the Applied Physics and Electrical Engineering Department. The research was supported by the National Science Foundation and the Air Force Office of Scientific Research.

The basic idea is simple enough — the new instrument can be thought of as microscopic sonar and its potential has been recognized for at least 30 years. The problem has been to create and focus sound waves at high enough frequency to reveal extremely small objects. As a rule of thumb, sound and light cannot form images of objects much smaller than their own wavelength, and to get wavelengths of sound comparable to those of ordinary light requires a frequency 100,000 times greater than any the ear could hear.

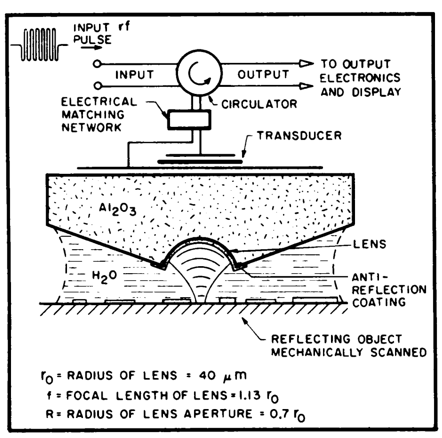
To solve this problem, Quate and his associates have pioneered development of a series of instruments that use films of piezoelectric material bonded to crystals to change electric currents into sound waves and back again. The waves generated by such a piezoelectric transducer are transmitted and focused by the crystal, strike the object under examination, and then are reflected back to the transducer for reconversion to electricity. (In another version, sound is transmitted through the object and detected by a transducer attached to a crystal on the other side.)

In their latest version, the Stanford team has produced sound waves with a frequency of 3 gigahertz (GHz=billions of cycles per second), and a wavelength of 520 nanometers — about the same as the wavelength of green light and giving a similar resolution of microscopic patterns. But unlike light, the reflected waves not only carry back information about the surface of the object under observation, they also reveal its internal structure to a depth of one or two microns. (A transmitting acoustic microscope can examine the structure of an object 5 to 10 microns thick.)



Illustrations: Stanford Univ.

Two views of computer element: Optical microscope looks at *the element, acoustic microscope looks* into *it (below).*



Configuration of scanning acoustic microscope as used in reflection mode.

The ability to "see" a couple of microns into an object may not seem spectacular at first, but this immediate subsurface region can have critical importance. Take integrated circuits, for example: Circuit elements are formed by depositing successive layers of material onto a crystal, and the success or failure of the circuit as a whole depends on having each junction well constructed. Acoustic microscopy promises a unique opportunity to detect flaws in such circuit elements, and a huge potential market is reportedly awaiting the new devices in this field alone.

Important biological applications also seem likely, although only preliminary investigations have been conducted so far. When a tumor spreads, the individual cancer cells appear to be able to slip through narrow channels that block normal cells. The difference in elasticity between these two kinds of cells does not reveal itself in a shift of refractive index (the ability of a medium to conduct light), but it may well show up under acoustic examination because the conduction of sound does seem to be different. Similarly, the diagnosis of blood diseases is likely to be made easier because abnormal blood cells stand out more clearly to an acoustic microscope.

In an interview with SCIENCE NEWS, Quate said the next step in his program will be to improve the resolution of the present instrument by perhaps a factor of two and decrease the scanning time from a few seconds to about a tenth of a second. (Scanning is done mechanically by passing an object back and forth in front of the sound beam.) A modest man who prefers to see his students take the limelight, Quate would speculate only cautiously about the ultimate impact of his instrument. Some private companies are considering commercial development, he says, but at least two years will be needed after the conclusion of negotiations to produce a marketable product. Such a commercial acoustic microscope would probably be priced less than a scanning electron microscope but still would be considerably higher than standard optical devices.

Meanwhile, the National Institutes of Health are considering funding further research into diagnostic possibilities of the Stanford machine and scientists from a variety of fields are beginning to realize they may have found a powerful new tool in acoustic microscopy. □