Light returns with resolve

The problem with light microscopes is light. It bends around apertures, blurring out images. The wavelength of light fundamentally limits how well a microscope can resolve two closely spaced point objects. But now researchers have found a way to circumvent this resolution limit by isolating a small bit of light before it spreads. Their new optical microscope, they say, will have a resolution comparable to the scanning electron microscope and will be an important tool in biophysics and electronic technology.

Scientists learned long ago that no matter how much they improved sample preparation techniques, light sources or lens aberrations in conventional optical microscopes, they could never hope to see details smaller than about half the wavelength of light — roughly a few hundred nanometers (nm).

That is why they turned to electrons. With shorter wavelengths, electrons increase the resolving power more than 100 times, enabling researchers to peer into the frontiers of microspace like never before.

But electron microscopes too have their problems. They are expensive and large. Moreover, the object to be examined must be coated in gold and placed in a vacuum. As such, electron microscopes are of little use to biophysicists such as Aaron Lewis at Cornell University in Ithaca, N.Y., who likes to study live specimens. And solid state physicists like Michael S. Isaacson, also at Cornell, are not too keen on having their semiconductor devices destroyed by the high energy electron probes.

So Isaacson and Lewis got together to do better with light. In a recent issue of ULTRAMICROSCOPY, they describe plans for a "scanning optical near field microscope" that they believe could have a resolution close to that of the scanning electron microscope (5 to 10 nm).

In a conventional microscope, light is collected from many different points on the specimen at once, allowing light waves from different regions to interfere. The trick to achieving high resolution in the new method is to place a very tiny aperture—smaller than the wavelength of light —very close to the surface of the object, within what is called the "near field." Thus light emerging from the sample directly below the hole is not given a chance to spread out and combine with light coming from other sections of the specimen. By moving the aperture in small steps across the sample, a complete spectral map of the object is constructed. The basic idea—a small hole held very close to an object—is what medical stethoscopes use to focus sound.

Researchers at IBM in Zurich have used this concept to develop, independently of the Cornell group, what they call an "optical stethoscope." The Zurich work, described in the April 1 APPLIED PHYSICS LETTERS, consists of one hole formed in a metal film at the end of a quartz rod. The Cornell microscope, on the other hand, is designed with an array of apertures to speed up the scanning process and let more light through. A computer is then used to sort out the intensity pattern.

In both systems, the resolution depends not on the wavelength of the light, but on the size of the hole. Isaacson says that his group can make holes in metal films as small as 4 nm with electron beam techniques. The practical limits involved in building a working microscope are insuring that the intensity of the light coming through the hole is strong enough to measure and that the aperture plate (or rod) can be held stably at very small distances from the object. At this point, the Cornell researchers are confident that a microscope can be built with a 50 nm hole, and hence, with a 50 nm resolution.

One surprise for the Cornell researchers is that they can easily see light from a 50 watt bulb through holes as small as 30 nm. According to the current theory governing electromagnetic transmission through small holes, considerably less light should get through. "The theory, which was designed for microwaves, may not necessarily hold when you're at atomic dimensions because it's a theory based on bulk properties," says Isaacson. "Apparently there is not that much known in this regime where the radiation is much larger than the aperture." A related theoretical question to be sorted out is how far the near field region extends — within a wavelength or the aperture size?

According to Isaacson, the new microscopes can use light that is reflected, transmitted or polarized. The Cornell group has also been able to detect laser-excited fluorescence through a 60 nm hole. Lewis is interested in using the new microscope to make "chemical maps" of living organisms by recording the spectral patterns as the wavelength of incident laser light is changed.

Isaacson also wants to extend the near field method to photolithography — the process of making patterns on semiconductor wafers in the fabrication of electronic devices. As circuit structures get smaller, he says, resolution becomes crucial. Here too scientists have turned to expensive electron beams to delineate delicate features. The recent work at Cornell and IBM shows that light can be used to achieve high resolution by placing a finely tooled lithography mask, or stencil, close to the device. In this way, says Isaacson, "We now have the possibility of making structures which are smaller than the wavelength of light." The problem now is to find photoresists — chemicals patterned by exposure to light—that are sensitive to increased resolution.

—*S. Weisburd*

Making eastern quake plans

The Federal Emergency Management Agency (FEMA) last week granted $300,000 to the Central U.S. Earthquake Consortium to use in compiling an emergency response plan should a major earthquake occur in the eastern U.S. The grant will cover the start-up costs of the consortium, which includes the states of Missouri, Arkansas, Illinois, Indiana, Kentucky, Mississippi and Tennessee. These seven states are likely to be most affected when a rupture occurs on the New Madrid fault (SN: 10/10/81, p. 232). This ancient fault system is responsible for the strongest quakes known in the United States.

In 1811 and 1812 three quakes with magnitudes of 8.6, 8.4 and 8.7 occurred near New Madrid, Mo., and rippled through much of the eastern and central United States. In many spots, the Mississippi River changed course, and several lakes were created in southern states. Though property damage was extensive, it is believed that few lives were lost because of the sparse population in the area at the time. Today, a major quake would cost untold numbers of lives, and billions of dollars in damage.

The last significant quake in the New Madrid zone was in 1895. With each passing year, strain accumulates on the fault, and the probability of a repeat event increases. Researchers say another major quake, magnitude 7.5 or greater, is likely by the end of the century. Because the crust in the eastern states is much more rigid than in already-fragmented areas such as California, damage would be much more intense, and would extend over a larger area. Advance planning among the seven states in the consortium could minimize disruption of transportation and communication, and of medical and social services, FEMA officials say. □

'83 catch: Anchovies lose

Overall, the United States' fish catch was up in 1983, but the amount of anchovies netted dropped to 22.3 million pounds, down from 103.3 million pounds in 1982. The National Marine Fisheries Service (NMFS) blames El Niño, an abnormal warming of the Pacific waters that has had marked effects on fisheries off the South American coast. Otherwise, the global climate disturbance seems to have had little impact on last year's U.S. fish catch. King crab catches were down, but the fisheries are too far north to have been much affected by El Niño. NMFS officials instead credit overfishing as the cause for the lowest king crab catch since 1959. Catch of American lobsters was up to a record 44.2 million pounds, topping 1982's record high of 39.4 million pounds. □