SCIENCE NEWS OF THE WEEK

Crystallizing Desirable Properties

World's first synthetic monolayer crystal.

Bell Telephone Laboratories

The discoveries of science have often given technologists the means of manipulating nature effectively and making the most efficient uses of natural processes in designing the artifacts of modern life. It is a case of art imitating life selectively and judiciously. Now we have a case of life imitating art. A group of physicists at Bell Telephone Laboratories in Murray Hill, N.J., Raymond Dingle, Arthur C. Gossard, Pierre M. Petroff, Albert Savage and William Wiegmann, report that they have produced a crystal nature never made. Their paper is in the Sept. 15 Applied Physics Letters.

Artificially built up by a process called molecular beam epitaxy, the material is called a monolayer crystal, one in which the composition of each layer of atoms is individually controlled. According to a Bell Labs announcement, it is the first synthetic monolayer crystal produced. Success in this procedure opens the possibility of making various kinds of crystals with desirable optical or electronic properties tailored in. Such artifacts could prove better for technological applications than Mother Nature's offerings.

These synthetic monolayer crystals have two basic advantages, Gossard told Science News: They are highly ordered, lacking the dislocations and impurities common in natural substances. This opens the possibility of building in any electrical or optical property for which order might be an advantage. The layering makes the crystal's structure highly anisotropic, and anisotropy also gives interesting optical properties. One of the capabilities of the specific crystal concerned in this announcement, basically made of gallium and arsenic, is polarization of light.

Molecular beam epitaxy is a technique by which crystals can be grown in a very controlled way to provide desired composition and dimensions, especially extremely flat, smooth surfaces. In an ultrahigh vacuum, beams of molecules or atoms of the substances out of which the crystal is to be made are directed against a selected substrate on which the crystal is built. The beams are controlled by shutters that start and stop them according to the composition of the desired crystal.

In the present case, the physicists started with a base of gallium arsenide. On this they laid down a layer of gallium atoms, then layers of arsenic, aluminum, arsenic and again gallium. Repeating the sequence hundreds of times produced a crystal resembling a highly polished mirror.

Molecular beam epitaxy has been used for years to grow high-quality semiconductor crystals. (In 1968 John R. Arthur of Bell Labs showed that was possible, and later Alfred Y. Cho, also of Bell Labs, developed the technique for fabricating microwave devices and semiconductor lasers.) But the method had never before been used to fabricate a crystal layer by layer. Therefore, even though the crystal's light-polarizing quality was presumptive evidence of its monolayer character, tests with a transmission electron microscope were run for confirmation. The short wavelength (0.02 angstroms) of the electron microscope and its high magnification allowed detailed study of the layer-by-layer construction of the crystal and verified its monolayer character. The background of the illustration is an electron microscope image of such an ultrathin layered structure.

Gossard declines to speculate on specific applications for monolayer crystals: "We're engaged in basic research," he says of himself and his colleagues. However, the new crystal has the same average composition as the crystals used in fabricating the light-emitting diodes that promise to be more and more used as the communications industry begins to employ light beams in optical fibers for signal transmission, so it is perhaps not an egregious misdirection to suspect possible applications there, especially for a polarizing crystal. Gossard also confirms that the group is working on production of other kinds of monolayer crystals. But he declined to name them because patent clearance for the new operations has not yet come, and the company naturally wishes to protect procedures that it has developed at its own expense until they are safely under patent protection. ☐

Viking: The quest for organic molecules

"It was supposed to get easier with the landers down," says Viking Project Manager James Martin, "but it doesn't seem to be happening." The four-spacecraft Mars mission, in fact, is proving so complicated and providing so much data that, combined with the pressure to get everything done before solar conjunction cuts off communications in November, the pressure on the 800-member flight team is just about as great as it was months ago when the first U.S. landing on another planet was the primary goal. Last week, when the first data came in from the biology instruments aboard Viking lander 2 in the Martian northlands, the exciting results just intensified the pressure.

The labeled-release experiment (LR), which monitors the rate at which radioactive carbon dioxide gas is given off from soil exposed to a nutrient containing carbon 14, showed an early release rate about 30 percent higher than that of the two active experiment cycles run by lander 1. At the same time, however, the gas-exchange experiment (GEx), looking for changes in the atmosphere surrounding a moistened soil sample, yielded an initial oxygen peak only about one-fifth the size of that from the first lander. One interpretation of the positive LR and GEx results from lander 1 was the presence of a strong oxidizing agent such as a peroxide, superoxide or ozonide. Indeed, the smaller initial oxygen peak in the lander 2 GEx data was consistent with such an agent, reduced somewhat in potential by the greater amounts of water expected at the lander 2 site from measurements of atmospheric water vapor overhead. "On the basis of those two thoughts," says LR team leader Gilbert V. Levin of Biospherics, Inc., "we might have expected to have seen less of a positive response in the LR experiment." Instead, it was even greater, suggesting the possibility that a more complex chemistry—or biochemistry—is at work, with two or more different oxidants involved.

Whatever the nature of the oxidants, their presence at both landing sites posed a separate problem in the possibly vital matter of detecting organic molecules in the soil, which would make some of Viking's biologists feel considerably easier about accepting living microorganisms as the explanation for their results. Originally, the second lander's organic chemistry instrument, a gas chromatograph/mass spectrometer (GCMS), was to have been given a soil sample from right next to the site of the biology sample. But