Atom clusters act bigger than their britches

Half a dozen atoms do not a semiconductor make — in theory, at least. But two physical chemists now describe a "totally astonishing" result that leads them to question the current theory.

Tiny clusters of indium phosphide atoms — which should behave much differently than the bulk material — show optical properties resembling those of the semiconducting bulk form, report Kirk D. Kolenbrander and Mary L. Mandich of AT&T Bell Laboratories in Murray Hill, N.J. While scientists offer widely varying interpretations of the experiment, some suggest that further investigations of this phenomenon might have far-reaching implications for semiconductor technology.

Theoretically, for a material to behave like a bulk solid, it must contain many atoms together. A group of two or three iron atoms, for instance, won't conduct electricity like a large iron rod. To understand the transition between atomic and bulk behavior, scientists have been studying clusters ranging from hundreds of thousands of atoms to fewer than 10.

Mandich and Kolenbrander say their experiment is the first infrared spectroscopic investigation of six- to 12-atom clusters. Theoretical considerations and experiments with other materials led the team to expect large optical differences between the indium phosphide clusters and the bulk solid. Instead, the clusters' infrared spectra revealed photon absorption at approximately the same energy ranges as those of the bulk solid, they report in the Oct. 22 PHYSICAL REVIEW LETTERS.

According to theory, electrons have energies in a range, or continuum, of permitted values. In contrast, electrons in individual atoms or in simple, nonsolid molecules have discrete energy levels. In a semiconductor, the term continuum band refers to the particular band of electron energies at which the material conducts electricity. An electron in a semiconductor will not absorb photons with energies that would put it into a forbidden region, or band gap, directly below the continuum band, but it will absorb photons with any energy that would put it into the conducting region.

Kolenbrander (now at MIT) and Mandich say they aren't sure why their indium phosphide clusters showed a continuum absorption band rather than distinct absorption levels. They speculate, however, that the tiny clusters must have some electron bonds similar to those in the semiconducting solid.

If they're right, the finding may represent a step toward molecular-scale semiconducting devices. In recent years, scientists have been considering indium phosphide as one possible replacement for silicon in microscopic electronic circuits. "Theory says . . . that if [clusters] get too small, they lose semiconducting properties. . . . But if the [band] is still there, it may be possible to make molecular-size integrated circuits, much smaller than anyone can do now," says chemist Michael A. Duncan of the University of Georgia in Athens.

However, the experimental result also has many possible explanations that do not involve semiconductivity, Duncan and others caution. There's no particular reason to believe that the band in the cluster has the same cause as the band in the solid, they say.

Mandich speculates that further studies of the cluster phenomenon may ultimately force physicists to revise their theories of amorphous solids — a class that includes some forms of semiconductors — to explain how such a tiny cluster can share properties with its bulk counterpart while apparently differing greatly in geometric structure.

She now plans to investigate other semiconductors, such as silicon, and slightly larger clusters of indium phosphide to see if they show similar spectra.

— R.N. Langreth

Menstrual glitches may spur bone loss

For the first time, research findings hint that "silent" abnormalities affecting the sex hormone progesterone can cause bone loss in young, healthy women. The new results suggest that subtle problems with the menstrual cycle can cause ongoing bone loss, a process that can lead to osteoporosis later in life.

The study's implications run counter to conventional thinking about osteoporosis. Scientists have blamed this crippling bone disorder primarily on a deficiency of the hormone estrogen, which slows the ongoing destruction of adult bone. The estrogen theory fits with the observation that many older women, who lose this hormone during menopause, experience rapid bone loss. In addition, scientists have held estrogen deficiency accountable for the bone loss plaguing some young female athletes who fail to menstruate.

Endocrinologist Jerilynn C. Prior started with a hunch that estrogen was only part of the osteoporosis story. She and her colleagues at the University of British Columbia in Vancouver set out to determine whether progesterone and/or exercise played any role in bone loss among a group of young women with no obvious menstrual difficulties.

The team focused on 66 women aged 21 to 42 who had normal menstrual cycles in the first two months of the study. The group consisted of 21 marathon runners, 22 recreational joggers and 23 women with normal activity levels. The researchers charted each volunteer's menstrual cycle, used an X-ray technique to estimate changes in spinal bone mass and developed a statistical method to reveal any correlations between bone density, exercise and menstrual cycle.

During the year-long study, they identified 28 women who had more than one menstrual cycle with a short luteal phase — the interval between ovulation and the beginning of menstruation — and another 13 women who failed to ovulate during at least one cycle. These 41 women (62 percent of the total) lost an average of 4.3 milligrams of spinal bone per cubic centimeter annually. In contrast, the 25 women who cycled normally showed no bone loss or gained a small amount of spinal bone during the year.

Prior notes that short luteal phases or anovulatory cycles frequently go undetected because they do not change the amount of blood flow or the total length of a woman's cycle.

When the researchers completed their statistical analyses, they saw no correlation between exercise and bone loss. Instead, they found that a short luteal phase or a cycle without ovulation strongly predicted bone loss, both for runners and for their less athletic peers.

"It was one of those exciting moments in science," Prior says.

A short luteal phase or a cycle without ovulation results in decreased blood levels of progesterone, she told SCIENCE NEWS. Evidence from many sources suggests that progesterone spurs the growth of new bone, she says. Prior's team observed that the women with the lowest blood levels of progesterone showed the greatest degree of bone destruction. Such findings suggest that bones need the proper *balance* between estrogen and progesterone to remain healthy, Prior asserts. She speculates that scientists might one day prevent bone loss in young women with luteal phase or ovulatory abnormalities by giving synthetic progesterone.

Prior has yet to prove the connection between bone loss and progesterone, cautions C. Conrad Johnston Jr. of the Indiana University School of Medicine in Indianapolis. Johnston, who co-authored an editorial accompanying the research report in the Nov. 1 NEW ENGLAND JOURNAL OF MEDICINE, says he "can't imagine" 60 percent of young women losing bone each year due to progesterone deficiency alone.

— K.A. Fackelmann