Gallium Arsenide: A Semi Goes Super

Though promoted for more than a decade as the semiconductor of the future, gallium arsenide has yet to upstage silicon-based computer chips. Now, scientists have discovered that the material has a hidden talent for superconductivity, and their serendipitous finding could be the break that gallium arsenide — and superconductivity itself — have long awaited.

When made with a little extra arsenic, gallium arsenide compounds can conduct electricity with no resistance at a temperature of 10 kelvins, according to a report in the June 10 PHYSICAL REVIEW LETTERS. The surprising finding was made by Jacek M. Baranowski of the University of Warsaw in Poland, working with a team led by Eicke R. Weber at Lawrence Berkeley Laboratory (LBL) in Berkeley, Calif.

If scientists can harness and control this property, "this would certainly revive a lot of the interest in gallium arsenide," says Arthur R. Calawa of MIT's Lincoln Laboratory in Lexington, Mass. "The implications are far-reaching."

The investigators stumbled onto superconductivity while studying defects in gallium arsenide films grown under various conditions by several other groups. They had detected irregularities in electron micrographs of one sample, and closer investigation revealed tiny, isolated regions of superconducting material embedded in the semiconductor film. These areas seemed to consist of aggregations of arsenic.

Usually, the cubic crystals of gallium arsenide contain equal amounts of the two elements. Yet when scientists make these crystals at low temperatures by molecular beam epitaxy — a technique that adds atoms one layer at a time — they find they can skew this ratio slightly. A few arsenic atoms sneak into spots in the crystal lattice where gallium normally resides, creating islands of pure arsenic within the mixed crystal.

Just a few years ago, Calawa had used this approach at MIT and had made the startling observation that just a little extra arsenic could turn the semiconductor into an insulator. "But no one has ever put this much arsenic into the material," he says, commenting on the LBL work.

"It really is a surprising and exciting development," says Arthur J. Freeman, a theoretical physicist at Northwestern University in Evanston, Ill.. "This has opened up a whole new class of materials as possible superconductors." He expects that other scientists will now make materials related to gallium arsenide and check them closely for this property.

Moreover, because scientists know so much about gallium arsenide and how to modify its structure and composition, some investigators expect the finding to lead to a better understanding of superconductivity itself.

"There's an awful lot of physics that could come out of this," says Gerald L. Witt, a physicist with the Air Force Office of Scientific Research in Washington, D.C., which helped fund the LBL study. "It offers the prospect of a test bed for understanding high-temperature superconductors." Although 10 kelvins seems low compared with the record 100-plus superconducting temperatures of ceramics, Witt suspects gallium arsenide and ceramics achieve superconductivity by related mechanisms.

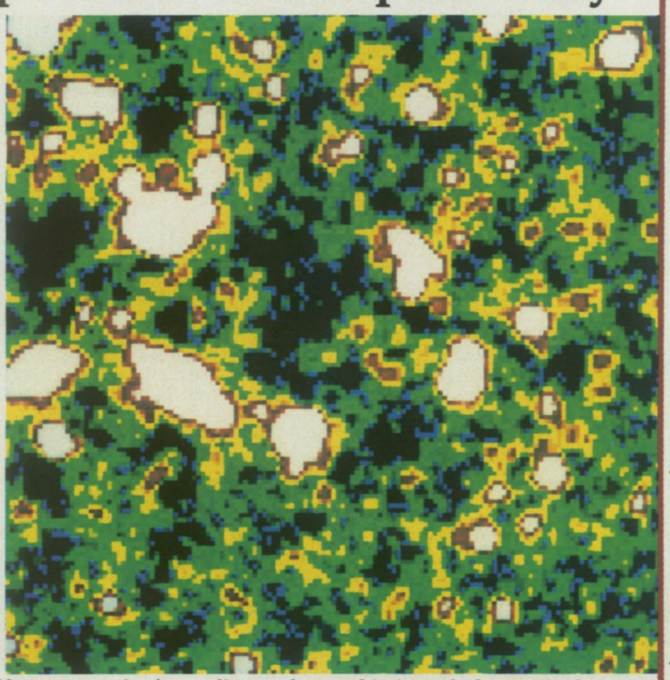
Superconductors increase the efficiency of electronic signals and speed their transfer — effects that can translate into faster computing. But the electronics industry has been slow to take advantage of these properties, or even to use gallium arsenide as a semiconductor. Now comes the appealing prospect of manipulating a single material so that separate parts of it are superconducting, semiconducting and insulating. Witt envisions future computer chips in which super- and semiconducting sections of gallium arsenide lie sandwiched between insulating films of the same material.

First, however, scientists must expand the islands of superconductivity into well-defined layers, says Weber. They must also determine whether gallium arsenide can superconduct enough current to be useful technologically, and then must raise the temperature at which the superconductivity occurs.

But Witt thinks the new discovery will spur many research teams to work toward such improvements. "There's going to be a flurry of activity," he predicts.

— *E. Pennisi*

Going deep to fill in a blank piece of sky


European Southern Observatory

Viewed with an ordinary telescope, a certain patch of sky in the direction of the constellation Sextans appears virtually empty — certainly devoid of any bright objects. But the European Southern Observatory's New Technology Telescope in La Serena, Chile, sees something quite different: an enormous number of extremely faint and remote galaxies that fill nearly the entire field of view.

To obtain an image of these dim galaxies, astronomer Bruce Peterson of the Mount Stromlo Observatory in Australia used a sophisticated electronic detector sensitive to yellow light to capture 41 10-minute exposures of this region. The individual pictures were then processed by computer and combined into a single, false-color image, a portion of which appears here (white brightest).

The picture shown corresponds to a region of sky about 1.1 arc-minutes wide (about one-thirtieth the width of the moon as it appears from Earth). It reveals a number of galaxies bright enough to display elongated shapes. It also shows many fainter galaxies. On the standard astronomical brightness scale, the dimmest of these objects have a magnitude of 29. No other ground- or spaced-based optical telescope has imaged an object this faint.

Astronomers are now making additional, more detailed measurements of these newly discovered celestial objects to try to distinguish between faint, nearby galaxies and extremely bright, distant galaxies.