der about the reliability of Flannery's dates for the Guilá Naquitz squash material. If the other crop fragments were as young as they now seemed, Flannery's dates would mean that several thousand years had passed between the domestication of the first crop, squash, and the widespread domestication of other crops, such as beans and corn. To Smith, that seemed implausibly long, in light of the abrupt appearance of farming-based civilizations in the Near East and Asia. "All these different lines of evidence seemed to suggest that it was worth taking a step out onto thin ice and predicting that [when dated using AMS] the Guilá Naquitz squash would turn out to be younger than people had initially proposed," says Smith.

In retrospect, that step wasn't warranted. In Mexico City last year, Smith retrieved the 13 seeds and other *Cucurbita* material Flannery had extracted from zones B through E of the floor of Guilá Naquitz (see diagram on previous page), layers spanning the period from 10,800 to 8700 years before the present. Smith's AMS dating of the seeds bore out Flannery's original estimates: One zone C seed proved to be 9900 years old, while five zone B seeds ranged from 8400 to 10,000 years old.

This effectively squelched the squash squabble. "What's exciting about Smith's data," says Flannery, is that the first American farmers "aren't getting younger—in fact, they may be a little older than we thought." Question marks still hang over the plant artifacts from MacNeish's Tehuacán sites; although most researchers agree that the new AMS dates there are trustworthy, MacNeish isn't ready to concede that his dating of the cave-floor layers was flawed.

Still, by all accounts, AMS dating is forcing ethnobotanists and archaeobiologists to rethink their definition of "farmer." "There's been a dichotomy of views: People can either be hunter-gatherers or agriculturalists," explains Smith. "In reality, there's a transition stage between these two, but we don't know much about it. And in Mesoamerica, it's clear that this 'transitional phase' was 6500 years long"—longer, Smith notes, than the hunting-gathering and farming phases put together.

The only way to fill in this picture, say Smith and other researchers, is to search out new troves of agricultural remains. Until then, says MacNeish, there will be "a lot of room for speculation, and a lot of very opinionated people."

–Wade Roush

MATERIALS SCIENCE

Will UV Lasers Beat the Blues?

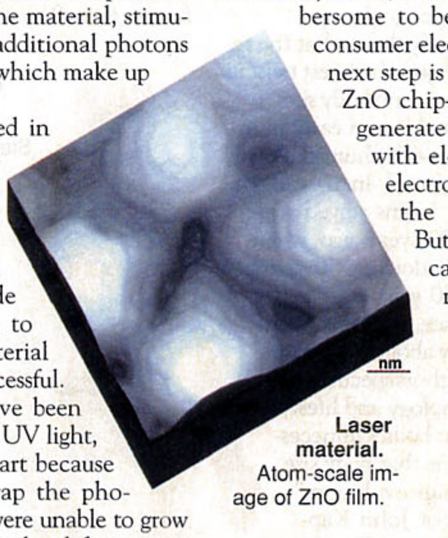
SAN FRANCISCO—The competition to make the next generation of compact-disc readers continues to burn white hot. At a meeting of the Materials Research Society held here last month, a team of scientists reported creating a new type of chip-based laser that generates the shortest wavelength light yet—ultraviolet (UV). If the experimental laser could be turned into a practical device, its short wavelengths would allow it to read CDs and CD-ROMs packed with far more information than today's versions can hold.

That could put the new device out front in the competition to succeed current CD lasers, which play a beam of near-infrared light over the tiny indentations that store data on a CD. Over the last few years, researchers worldwide have been racing to commercialize other chip-based lasers that emit shorter wavelength blue light, which—by allowing the use of even tinier indentations—could increase fourfold the amount of data stored on discs. But the new laser, based on the semiconductor zinc oxide (ZnO), promises even greater gains.

The device was developed by ceramics researcher Masashi Kawasaki and his colleagues at the Tokyo Institute of Technology in Yokohama, the Hong Kong University of Science and Technology in Kowloon, and the Institute of Physical and Chemical Research (RIKEN) in Sendai, Japan. "It's great work," says Chang-Beom Eom, an associate professor of materials science at Duke University. The device now has to be pumped with light from another laser, but if the researchers can adapt it to run on electric current, says Eom, it "means the density of data storage can go even higher."

At the heart of all chip-based lasers are semiconductor materials that allow electrons to exist at only specific energy levels, or "bands." Incoming energy excites the electrons, boosting them from a low-energy to a high-energy band, and leaving behind positively charged vacancies in the lattice structure of the semiconductor crystal. In a laser, the energized electrons give up their excess energy as photons of light when they fall back down into the vacancies. Mirrors flanking the semiconductor then toss the photons back and forth through the material, stimulating the generation of additional photons at the same wavelength, which make up the laser's beam.

In semiconductors used in conventional lasers, the energy gap between the high- and low-energy bands is too narrow to generate UV photons. In ZnO, this gap is wide enough, but past efforts to build lasers using the material have been largely unsuccessful. Although the crystals have been coaxed to emit photons of UV light, the emission is weak, in part because defects in the crystals trap the photons. When researchers were unable to grow bulk ZnO crystals without the defects, most gave up on the material for making lasers.



Laser material. Atom-scale image of ZnO film.

M. KAWASAKI/TOKYO INSTITUTE OF TECHNOLOGY

Kawasaki and his colleagues took a different approach. Using a sort of high-tech, atomic spray-painting machine, they were able to create thin, nearly defect-free, ZnO films made of tiny crystalline grains laid down in a honeycomblike pattern. When team members bombarded the film with a light beam, they found that the film absorbed the energy and reemitted it as a surprisingly intense UV laser beam. Kawasaki believes that the sharp boundaries between illuminated and dark portions of the film act as tiny mirrors to reflect UV photons into a coherent beam. The film's honeycomb structure also may help excited electrons to combine with positively charged vacancies to produce photons, he says, although the exact mechanism there is not yet clear.

For now, the new films only produce UV laser light when their electrons are energized with blasts of high-energy photons from big, laboratory lasers, which are much too cumbersome to be adapted for use in consumer electronics products. The next step is developing compact, ZnO chip–based lasers that will generate a beam when jolted with electrical current from electrodes above and below the semiconductor film. But that won't be easy, because vacancies don't move as easily from the anode through ZnO as they do in other materials, says Jeff Cheung, a materials scientist at the Rockwell Science Center in Thousand Oaks, California.

Cheung and others recently succeeded in enhancing the positive conductivity of ZnO films by spiking them with trace amounts of nitrogen. If such doping techniques allow ZnO lasers to make it to market, they probably will have another advantage over the competition. ZnO films can be grown at about 500 degrees Celsius, hundreds of degrees lower than gallium nitride, the most popular material for blue lasers. Call it a cool way to beat the blues.

–Robert F. Service