their spawning grounds, and may reveal migration routes as well.

"Fisheries managers try to define a group of fish that are a single population, grow at the same rate, and come from the same spawning ground so we can manage them properly," says Campana. But determining the size of that population can be hard if other groups keep mixing in. So managers are starting to use otolith elemental composition to tell stocks of fish apart. Campana and his colleagues recently studied cod from spawning grounds throughout the North Atlantic and showed the combinations of trace elements in the otoliths were distinctive enough for researchers to match the otolith—and the cod around it—to a spawning ground with 80% to 90% accuracy.

At the moment, this type of work is limited by the technology used to detect the elements. The most common method is x-ray microanalysis, in which x-rays emitted by different elements after electron bombardment form a characteristic pattern that shows up on a detector. The problem is that a high concentration of the element is needed for the pattern to show up—higher than 100 parts per million, usually—and that means that researchers are limited to searching for a few elements, such as strontium, that are present at a high level.

Because of its relative insensitivity, the x-ray technique is most useful in situations "such as the migration of fish through waters of incredibly different chemistry, so different that we're dealing with estuary or ocean," says biologist John Kalish from the Australian National University in Canberra, Australia. Kalish has looked at the elemental composition of the otoliths of river-spawning and sea-spawning trout of the same species. He was able to discriminate between the two based on the higher strontium/calcium ratio in the sea-spawning variety. The more salt there is in the water, the more strontium there is as well, so there is a higher strontium/calcium ratio in the otoliths of sea-going fish.

More sensitive tools may find subtler differences. Currently Campana, along with Tony Fowler at the Bedford Institute and Cynthia Jones of the Applied Marine Research Laboratory at Old Dominion University, Virginia, are experimenting with a new laser-based technology. They aim the laser at a segment of the otolith, vaporize it, and the resulting gas is analyzed by a mass spectrometer, an instrument that detects elemental particles in that gas at parts per million and even parts per billion.

Campana, Fowler, and Jones plan to use the laser to tease out copper, cadmium, and zinc from otoliths. They've collected fish from two different rivers, one polluted and one relatively pristine, and hope that the heavy metal ratios, associated with pollution, will distinguish the fish. If they do, researchers can use the data when they examine fish of unknown origin to figure out where the fish has been swimming.

By analyzing successive weekly collections of rings, and linking their elemental fingerprints to specific waters, Campana, Fowler, and Jones also hope to be able to track the fish over its lifetime. "If we can start discriminating between locations with fair accuracy then we can start looking at finer and finer differences, temperature differences, salinity exposure, pollutant exposures," says Jones. "If the signal is strong enough, that could allow us to nail down in time and space where the fish have been and for how long." In addition, the otoliths of fish killed by pollution could lead authorities back to the very source of that pollution.

One possible hitch in element analysis is that hormonal changes in the fish—such as those that accompany pregnancy—may affect the chemical composition of the otolith, leading to false element signatures. Biologists are currently debating whether trace elements, which are not important to the physiology of the fish, are actually affected by hormonal changes.

Ultimately, if the technique proves accurate enough, fisheries scientists hope it will allow them to start asking pointed questions with international consequences, such as: "Who's fish are you fishing? Mine or yours?" For instance, a foreign poacher caught with a load of fish on a pier, falsely claiming it came from other waters, could be hooked and reeled in. A current dispute in which Newfoundland inshore fishermen claim that offshore ships are taking their fish—fishermen on the ships claim the fish are from two different stocks—could be resolved. All in all, there's a lot to be learned from the inside of a fish's head.

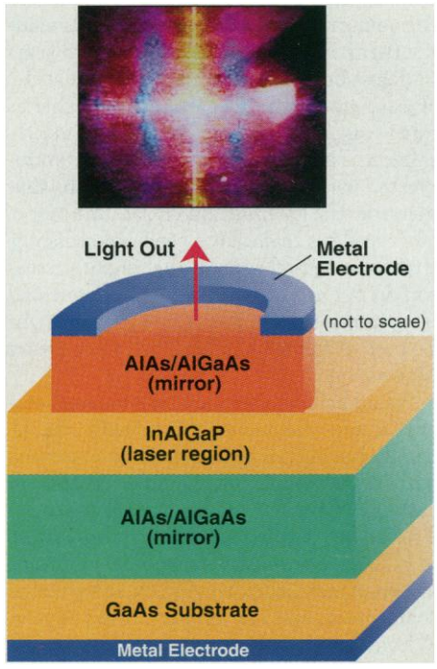
–Suzanne Kingsmill

Suzanne Kingsmill is a science writer based in Quebec, Canada.

TECHNOLOGY

New Laser Serves Red Light, Straight Up

Tiny lasers-on-a-chip have been technological darlings for a long time. Theirs is the light that scans compact discs and beams down glass optical fibers. But commercial semiconductor lasers emit their light from the edge of the chip, which makes it difficult to combine them in arrays that might, say, power a set of optical fibers. As a result, researchers have been trying to develop lasers that direct their light up through the top of a chip instead of out the side. But they've had little success in turning such lasers into efficient, practical emitters of the visible light prized for many applications. Now, researchers at Sandia National Laboratories have fashioned tiny surface-emitters that just may pass technological muster.



Lasing around. A multilayer stack of semiconductor materials shows off its ability to emit bright red laser light by bleaching photographic film *(top)*. The diagram shows the anatomy of the 10-micron-wide structure.

SOURCE: SANDIA NATIONAL LABORATORY

In the 13 May issue of *Electronics Letters*, Sandia materials scientists Richard Schneider and James A. Lott report a new wrinkle on a technology familiar in the optoelectronics world—that of the so-called vertical cavity surface emitting lasers (VCSELs), pronounced "vixels." VCSELs consist of minuscule, multilayered stacks of semiconducting materials and emit light straight up. But until recently, the difficulty of combining different semiconductors in layers of exactly the right geometry to generate visible light had limited most VCSELs to invisible infrared light. Those few that have emitted visible light have done so only when pumped with another laser. The Sandia device overcomes those handicaps, efficiently emitting red light when pumped with an electric current.

To make their VCSEL, the Sandia scientists relied on a fabrication technique known as metalorganic vapor phase epitaxy, which enables them to build up complex multilayered constructions, molecular layer by molecular layer. The light-emitting heart of these constructions is the optical cavity, composed of several 10-nanometer-thick layers of the semiconductor indium-aluminum-gallium-phosphide. The cavity's quantum mechanical properties, which depend partly on

the precise thicknesses of its layers, the specific semiconductors used, and the mechanical strain between adjacent layers, turn it into so-called quantum well in which electric charges approaching from the layers above and below it get trapped and recombine to emit red light.

Bounding the cavity are complex "mirrors" made up of alternating sublayers of aluminum arsenide and aluminum gallium arsenide. The mirrors reflect and amplify the emitted light and pave a low resistance pathway into the cavity for electrons and "holes"—mobile positive charges. The electrical current that drives the laser enters through metal electrodes that are deposited onto the very top and bottom of the multilayered structure.

This intricate device has already caught the eye of such electronics giants as Hewlett Packard, Honeywell, Xerox, and others, some of which have expressed interest in collaborating with Sandia to develop it into a full-fledged technology. There are good reasons for their interest, as laser maker Connie Chang-Hasnain of Stanford University points out. The new VCSEL's unique combination of features, she says, "opens up a lot of applications." One possibility, suggests Robert Thornton of the Xerox Palo Alto Research Center (PARC), is that the new VCSELs could end up muscling in on existing niches for red lasers such as the scanners at grocery checkout counters, which now rely on bulky, power-eating helium-neon gas lasers. Moreover, Schneider speculates, the new VCSEL could earn the status of an "enabling technology," one that eases the way for a host of other technologies.

Plastic optical fibers, for example, get lip service as a cheaper alternative to glass fibers for short-haul (intraoffice or intracity) optical communications but are still awaiting a suitable light source. So far, even edge-emitting lasers haven't produced the wavelengths best suited to plastic fibers in a beam of high enough quality. The new surface emitter, however, may fit the bill, says Schneider. "It is conceivable that on one 2-inch wafer, we could grow at least 10,000 little devices, each one putting out enough power" to pump light through a fiber, Schneider says.

Before technologies based on the new laser start to proliferate, Schneider concedes, there are bugs to work out. For one, the flow of electrons into the quantum wells is uneven, enabling the new VCSELs to lase only about 40% of the time even though their light looks continuous to the eye. For printing and scanning, he adds, continuous lasing is a must. Also, all of that exquisite layering takes skill, patience, and expensive equipment, Chang-Hasnain says. But with a host of potential applications pending, nobody is going to turn the lights out on these new little lasers any time soon.

–Ivan Amato

CANCER RESEARCH

New Tumor Suppressor Gene Captured

Step by step, base pair by base pair, researchers have finally closed in on the gene that causes von Hippel-Lindau (VHL) disease, a rare but deadly condition that predisposes affected individuals to a surprising variety of cancers, including those of the eye, the kidney, and the brain. On page 1317, an international team of scientists from the National Cancer Institute (NCI) in the United States, Cambridge University in England, and France's Centre d'Etude du Polymophisme Humain report that they have nabbed the elusive gene.

The new gene is "an important one to know about. It's really nice to have it join the club."
—Alfred Knudson

"They definitely have it and it's very exciting. It means real help for the von Hippel-Lindau families," says Wayne State University molecular geneticist David Smith, who was also racing to find the gene. Smith and others believe the discovery will lead to better diagnosis and improved monitoring of patients with the disease, and perhaps to new therapies as well.

What's more, the work confirms that the VHL gene is a tumor suppressor gene. As their name suggests, these genes, currently numbering fewer than a dozen, normally inhibit tumor cell growth, and it's their loss or inactivation that predisposes to cancer. The VHL gene is "an important one to know about. It's really nice to have it join the club," says Alfred Knudson of Fox Chase Cancer Research Center in Philadelphia, whose work more than two decades ago laid the foundation for current tumor suppressor gene research.

Winning the race to the VHL gene was a matter of hard work, a strong collaborative effort between clinicians and basic scientists, and a few strokes of luck, says one of the paper's authors, Michael Lerman of NCI's Frederick Cancer Research and Development Center. By doing classical genetic linkage studies in VHL families, researchers in 1988 first mapped the disease gene to a small region at the tip of the short arm of chromosome 3 and have since further narrowed the suspect area. After cloning that section of DNA, it quickly became a matter of pulling out the genes there and testing each one to see if it was consistently deleted or mutated in VHL patients. If so, it would mean the researchers had their tumor suppressor gene.

The VHL collaboration had at least one false alarm. They found a gene, which encoded a calcium pump and looked like a good candidate because it's active in the tissues where VHL cancers arise. But within weeks the team found a VHL patient whose deleted area on chromosome 3 did not include the calcium pump gene—almost definitive proof it was not the VHL gene. But fortune smiled on the gene hunters as they quickly located a second VHL patient who had a deletion within the first patient's missing region, and then a third patient whose deletion was inside the second's.

Like a Russian doll that gets smaller and smaller, these serendipitous nested deletions further narrowed the location of the VHL gene, explains coauthor Berton Zbar of NCI. Then, by analyzing the cloned DNA from the region defined by the deletions, the collaborators spotted two new candidate genes, one of which proved to be their quarry. It, too, was active in the tissues where VHL cancers strike, and the gene had changed very little in the course of evolution, a finding that suggests that it performs a very basic cellular function.

The clincher, however, has been extensive mutational analysis. For example, the group has found parts of the gene missing in "spontaneous" cases of VHL, instances where neither parent carries the disease gene but their child is afflicted. This indicates that these cases were caused by a newly arising deletion. A group led by NCI's Marston Lineham also detected mutations of the gene in cell lines from a sporadic type of kidney cancer, which is common in VHL patients.

The job of the VHL collaboration is certainly not over. Parts of the VHL gene remain to be sequenced, but the sequence obtained so far shows that the gene encodes a protein with no similarities to other tumor suppressors. "It already looks like it will be a new type of tumor suppressor gene," notes Lerman. The bad news is that the sequence provides few clues to the novel gene's function.

Researchers should have the gene's full sequence within the year, and a 100% accurate diagnostic test for VHL should soon follow. Researchers also hope they will be able to correlate specific mutations on the gene with the distinct forms of cancer that strike different VHL families. This could greatly improve patient monitoring by suggesting which tumors to look for most carefully, explains Zbar. Right now, notes Smith, those with the VHL gene contain "a ticking time bomb, and they don't know where it will go off." Having gene in hand, however, will help researchers defuse that danger.

–John Travis