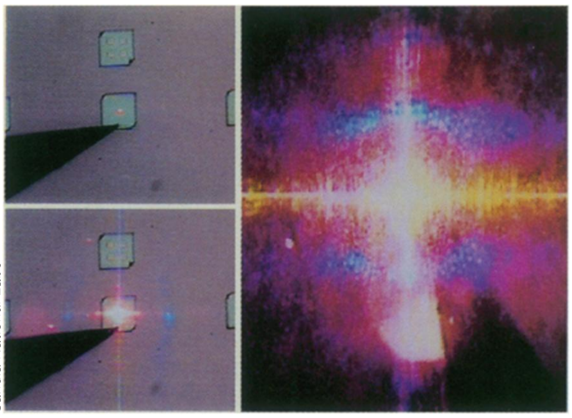
Red laser light gets an electric charge



Photos taken through optical microscope capture the electrically injected VCSEL as it beams red light. An injection probe stimulates device placed on 100-micron test pad (upper left). The device emits light in a star-shaped pattern through a 10-micron aperture (lower left). With room lights off, the VCSEL lases brightly (right).

Lasers – devices that produce intense monochromatic beams of electromagnetic radiation – are rapidly lighting the way to advances in communications technologies. Now, laser-based systems for storing, presenting, and moving data may benefit from a new semiconductor laser with potential uses in optical information processing, laser printers and displays, and scanners that read bar codes at supermarket checkouts, two materials scientists report in the May 13 Electronics Letters.

Richard P. Schneider Jr. and James A. Lott, both at Sandia National Laboratories in Albuquerque, N.M., have created a vertical-cavity surface-emitting laser (VCSEL) that should bring this promising class of devices closer to commercialization. Most semiconductor lasers used today emit their light from the cleaved edges of a crystal. The much smaller VCSELs, however, emit a more focused swath of light from the top surface. Scientists can closely pack an array of these devices on a chip to produce tight, circular laser beams (SN: 7/29/89, p.68).

The Sandia team has now developed a VCSEL that emits visible light and operates using electricity – two significant advances, says Schneider. Until now, the shortest wavelength reported for a VCSEL was 699 nanometers, just at the edge of the visible-light spectrum. The new VCSEL lases bright red light at wavelengths of 639 to 661 nanometers. Scientists are interested in shorter wavelengths because they're visible to the human eye and can carry and detect smaller informational features, says Schneider.

To make their VCSEL, he and Lott used metalorganic vapor phase epitaxy, a technique for stacking perfect crystalline layers into a semiconductor "sandwich." Thin layers of metallic phosphides containing indium, aluminum, and gallium make up the optically active region, which determines the wavelength of the resulting beam. Alternating layers of aluminum arsenide and aluminum gallium arsenide act as reflectors, sending light waves out the top surface of the material.

Even more important, Schneider says, he and Lott managed to stimulate light emission through electrical injection. Before that, they depended upon another laser to charge their VCSEL – hardly practical in everyday applications. "You want to be able to plug something into the wall," says Schneider. "We knew we wouldn't have a 'real' device until it operated with electrical injection. That's the breakthrough here."

The team is now trying to boost the device's electrical efficiency and coax it to produce other colors of light.

– K.F. Schmidt

Testing theory by computing quark behavior

Donald Weingarten sits between cabinets housing some of the processors of the specially designed GF11 supercomputer, which an IBM team used to calculate from theory the mass ratios of certain subatomic particles.

It took nearly a year to do the calculations, but when the computer finally disgorged the numbers, physicists had for the first time extracted from theory predictions of the ratios of the masses of eight subatomic particles. These computed, theoretically derived ratios differ from experimentally observed values by less than 6 percent.

The results provide the strongest quantitative evidence yet that quantum chromodynamics (QCD) is correct, says Donald Weingarten of the IBM Thomas J. Watson Research Center in Yorktown Heights, N.Y. Quantum chromodynamics equations describe the characteristics and behavior of quarks and the peculiar force that binds different quarks and antiquarks together to create protons, neutrons, and other subatomic particles known as hadrons.

Weingarten and his co-workers report their findings in the May 10 Physical Review Letters.

The IBM group did their calculation using an experimental supercomputer known as the GF11, designed and built at IBM specifically for this task (SN: 8/10/85, p.88). The computer, which fills a large room, has 566 processors – each a powerful computer in its own right – that operate together in various combinations. "It's a big, complicated machine," Weingarten says. "It took a while to get it debugged."

Even with a specially designed supercomputer on hand, the researchers had to adopt certain approximations to simplify their QCD calculation so that it could be completed within a reasonable time. For example, like most other groups studying QCD, they used a so-called lattice formulation of the theory, in which each point, or node, within the lattice corresponds to a particular set of quark and antiquark positions and a given geometry for the force field acting on the particles.

Researchers can then calculate the probability that a certain quark-antiquark combination will shift from its initial state to a new state – that is, from one node to another in the lattice. These transition probabilities provide the raw numbers from which theorists can deduce such particle characteristics as the mass ratios of hadrons.

Because the calculations must be done repeatedly for the many nodes in a typical lattice, this tedious but necessary procedure consumes a vast amount of computer time. As the lattice size increases and the spacing between the nodes decreases to bring this approximation of QCD closer to the full theory, the required number of calculations escalates tremendously.

The IBM effort represents the first full calculation of hadron masses from QCD, Weingarten says. Previous calculations by a number of other groups either were incomplete or were used as tests of the computational methods themselves.

"I feel that we've reached a milestone," Weingarten says. "On the other hand, the fun is just beginning. Now that we really know how to calculate real numbers, there's a whole bunch of interesting things . . . we'd like to go out and learn [about QCD]."

– I. Peterson