the spectrograph, says Peter Stockman, deputy director of the Baltimore-based Space Telescope Science Institute, which coordinates Hubble observations.

Preston Burch, NASA's deputy project manager for Hubble operations and ground systems, says engineers will begin tests next month to gather more information on the equipment failure. They hope to determine whether changes in such factors as the spectrograph's temperature can boost the power supply's performance enough to allow more frequent and predictable data transmission by side 2. The tests could take up to a month to complete, Burch says.

If testing does not suggest a way to improve the power supply, NASA still has two key options for salvaging the spectrograph, says Goddard astrophysicist Sara R. Heap, a member of the spectrograph research team. Using software relayed from the ground to the telescope, researchers could attempt to connect side 2 to a second onboard formatter, which does not use the defective voltage source. The formatter change could take two to three months. Although side 1 would remain inactive, a successful switchover should fully revive operations with side 2, Heap says.

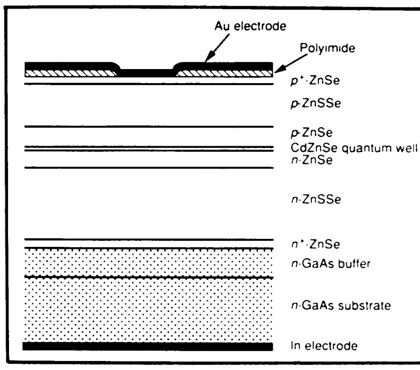
But the undertaking poses some formidable risks, she adds. Hubble's four other science instruments – which now function normally – would also have to switch to the second formatter, requiring ground-based technicians to temporarily turn off their power, place the instruments in an inactive "safe mode" for several days, and then power them back up. Power surges inherent in this process might damage equipment, notes Burch. Moreover, says Heap, the second formatter has not been tested in space. Some scientists worry that if this formatter does not operate properly, the engineers may have difficulty switching the instruments back to the original device.

"It's like a chess game," says Burch. "You don't want to make a move you don't know how to deal with, or you might get checkmated." The formatter change remains a possible option, he says, but if it caused a working instrument to fail, "we'd really look like a bunch of fools."

A second option would involve a fix in space, attaching a working power supply to the spectrograph and leaving the faulty supply intact but disconnected. NASA would piggyback this effort on a Hubble service mission already planned for 1993. The maneuver – similar to the 1984 repairs on the Solar Maximum Mission – would require an extra day on the three-day service mission, says John Campbell of Goddard, the deputy associate director for Hubble flight projects. After all, he notes, astronauts on the service mission will already have their hands full fixing Hubble's blurry optics, failed gyroscopes and loose solar panels.

– *R. Cowen*

Pushing lasers on a chip into the blue



3M Co

Cross section of blue-green laser diode.

Semiconductor lasers serve as the most compact, inexpensive sources of light available for use in such products as compact disk players and laser printers. They normally emit red or infrared light, but industrial researchers have now fabricated semiconductor lasers that generate pulsed light at a considerably shorter wavelength.

Using a layered crystal composed largely of zinc selenide, Michael A. Haase and his co-workers at 3M Co. in St. Paul, Minn., electrically induced their novel material to emit blue-green light, the shortest wavelength ever generated by a solid-state laser. That success, reported in the Sept. 9 APPLIED PHYSICS LETTERS, marks a significant step toward producing commercial semiconductor lasers that generate blue light. Such lasers would permit the storage of much larger quantities of data and the printing of finer details.

"It's a great achievement," says electrical engineer Jacob B. Khurgin of Johns Hopkins University in Baltimore. "Five or six years ago, lots of people were giving up on the idea of making [blue-green] lasers out of zinc selenide."

A semiconductor diode laser generates light at a junction within the material where negative charge carriers, or electrons, recombine with positive charge carriers known as holes. The energy difference between the electrons and holes determines the wavelength of the emitted light.

Researchers had known for more than three decades that zinc selenide has the right characteristics to generate blue or blue-green light. But until recently, progress was stymied by the immense difficulties of devising a crystal structure that effectively confines electrons to an extremely thin layer and introducing appropriate impurities into zinc selenide to generate a sufficient number of positive charge carriers.

Last year, physicists at the University of Notre Dame in Indiana finally solved the confinement problem by sandwiching a thin layer of zinc selenide mixed with cadmium selenide between layers of zinc selenide. The zinc-cadmium layer acts as a "quantum well" to trap mobile electrons and holes in a small region of the crystal.

"The development of this material was a crucial step," says Notre Dame's Jacek K. Furdyna.

"It seems to be the most promising system for the time being," adds colleague Nitin Samarth. "Everyone's using it."

The problem of introducing holes into zinc selenide was also solved last year when scientists at 3M and the University of Florida in Gainesville developed a way of embedding nitrogen in the material. That technique involves exposing the material, as it forms, to nitrogen gas excited by radio waves.

These two developments allowed the 3M team to fabricate the first layered crystal capable of generating blue-green light when activated electrically. "The fact that they were able to put these two pieces together represents a dramatic breakthrough," says Arto V. Nurmikko of Brown University in Providence, R.I. At a conference last week in Japan, Nurmikko announced that his group, together with researchers at Purdue University in West Lafayette, Ind., had also constructed such a laser and confirmed the 3M result.

The prototype zinc cadmium selenide laser, barely the size of a sand grain, produces pulses of light at a wavelength of 490 nanometers when cooled to the temperature of liquid nitrogen (77 kelvins). At room temperature, the wavelength increases to roughly 500 nanometers.

"We've now built more than 100 lasers," says Charles Walker, who heads 3M's photonics research lab. But commercialization remains several years off, he adds.

One problem centers on the excessive heat generated when the laser operates. Although it takes a relatively high voltage to drive the laser, only a small portion of that energy ends up as light. The rest turns to heat, which limits how long the laser can operate without destroying itself. To produce light as a continuous wave instead of as brief pulses, researchers must find ways of reducing the voltage needed to drive the device.

One sign that continuous-wave operation is feasible appears in a separate paper in the Sept. 9 APPLIED PHYSICS LETTERS, in which the Notre Dame and Brown groups jointly report that an optically driven zinc cadmium selenide laser can generate light continuously at temperatures up to 110 kelvins.

– *I. Peterson*