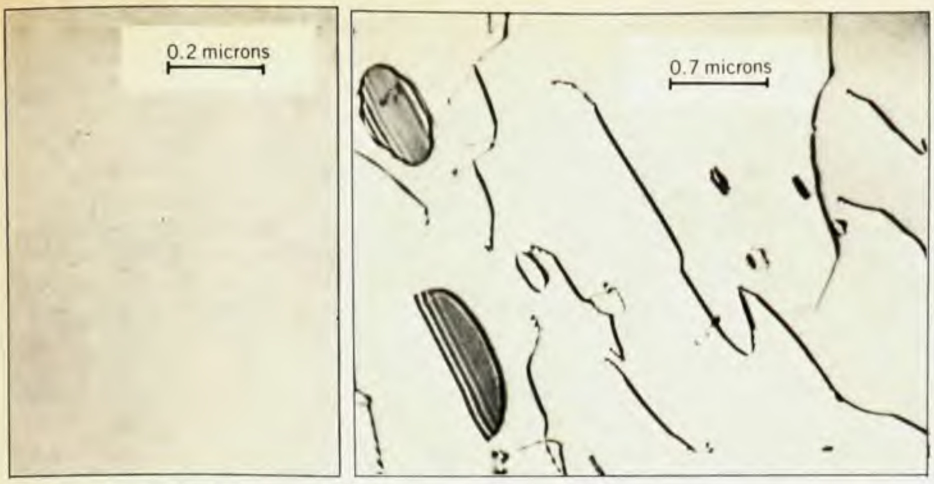

No damage is visible in the sample on the left, annealed by a single pulse from a Q-switched ruby laser, while the sample on the right, subjected to thermal annealing at 1100°C for 30 min, shows extensive lattice damage. Both samples are boron-implanted silicon. Photo from Rosa Young.

cessively in 8-micron steps; their argon-ion laser has annealed regions as small as 1.6 microns. They have also done annealing studies in ion-implanted gallium arsenide, for which laser annealing appears particularly attractive, because thermal annealing causes GaAs to decompose.

The interest in laser annealing is worldwide; active groups cited by Gibbons include the University of Catania (Italy), Hitachi Central Research Laboratories and Toshiba R&D Center (Japan), Philips Research Lab and FOM Laboratory (Netherlands), Atomic Energy Research Establishment, Harwell (UK) and the Hopei Institute of Semiconductors (People's Republic of China). Laboratories in the US with active programs in progress include, in addition to the ones mentioned, Lockheed Palo Alto Research Labs, Caltech, RCA, Rockwell Science Center, Air Force Geophysics Labs, Hughes Research Labs, Hewlett-Packard and Texas Instruments, according to Gibbons.

A related method for ion-implant annealing is the use of pulsed electron beams, being developed since 1973 by Allen Kirkpatrick and his associates at the SPIRE Corp, Bedford, Mass. They report solar cells of 15% efficiency, produced in a high-speed production process.[4] Their method employs a 10-keV electron beam 7 cm in diameter in 0.1-microsec pulses. Kirkpatrick feels that the large processing area and effective energy utilization make pulsed electron beams particularly attractive for large-scale production. —HRL

References

1. R. T. Young, C. W. White, G. J. Clark, J. Norayan, R. D. Westbrook, W. H. Christie, in *Proceedings* of the Luxembourg Photovoltaic Solar Energy Conference (27–30 September 1977), D. Reidel, Boston (1978).
2. A. Gat, J. F. Gibbons, T. J. Magee, J. Peng, V. Deline, P. Williams, C. A. Evans Jr, Appl. Phys. Lett. **32**, 276 (1978).
3. W. L. Brown, J. A. Golovchenko, K. A. Jackson, L. C. Kimerling, H. J. Leamy, G. L. Miller, J. M. Poate, J. W. Rodgers, G. A. Rozgonyi, T. T. Sheng, T. N. C. Venkatesan, G. K. Celler, in *Proceedings* of the Conference on Rapid Solidification Processing—Principles and Technologies (13–16 November 1977, Reston, Virginia), Claitors Publishing Division, Baton Rouge, La.
4. A. R. Kirkpatrick, J. A. Mennucci, A. C. Greenwald, IEEE Trans. Electron Devices **ED24**, 429 (1977).

Fusion computer center expands at Livermore

Groundbreaking for a new building to house the National Magnetic Fusion Energy Computer Center recently took place at Lawrence Livermore Laboratory. The $5-million, 44 000-square-foot facility is scheduled for completion in February 1979, and will house two large computers, a Cray-1 and a CDC 7600.

The NMFECC was founded in 1974 to provide large-scale computational support to the US magnetic fusion-energy community (PHYSICS TODAY, October 1974, page 19). Presently housed in a World War II vintage barracks building, it has 55 employees and a $6-million operating budget from the Department of Energy in 1978.

The Center's most powerful computer, a Cray-1, was installed in April. (It has the same configuration as the computers being used at the National Center for Atmospheric Research and at Los Alamos.) The Cray-1 is a vector computer able to set up many operations simultaneously. It can perform 138 million floating-point operations per second over a sustained period of time; an even higher rate of 250 million operations per second can be attained in short bursts. The computer has a one-million-word semiconductor memory. Four Cray Research DCU-2 disk control units, each controlling four DD-19 disk storage units, make up the disk storage system; together the storage units hold nearly 2½ billion bits of useful data. The Center's CDC 7600 computer can perform 20 million mathematical operations per second. It has 65 000 words of semiconductor memory and 512 000 words of magnetic core memory.

The Center also has a CDC 6400 computer for file management and two PDP-11/50 computers—one for central communications control and the other for network control. A 500-billion-bit CDC 38500 mass storage device is planned for operation late this year.

More than 800 researchers have access to the Center's computers. At seven fusion research centers located at various points in the US, user service centers each have a PDP-11/40 computer functioning as a remote control communications processor and a PDP-10 computer that allows the service center to function as a remote output or a remote job entry station. Thirty other fusion research groups at universities, national laboratories and industry have access to the Center through dial-up telephone lines from remote terminals. —CBW

Interacting-boson model

continued from page 17

nuclear physics. Proponents of the interacting-boson model think that, on the contrary, nuclear physics may be a very rich field for theories involving symmetries.

In addition to emphasizing symmetries in nuclear physics, the model is also useful in analyzing experimental data in medium and heavy-mass nuclei. Most of these data have been analyzed in the past in terms of the collective model of the nucleus developed by Aage Bohr and Ben Mottelson in Copenhagen, and for which they won the 1975 Nobel Prize. In their earlier work on the model, one describes the nucleus as a liquid drop capable of performing oscillations and rotations. The model has been extremely successful in describing deformed nuclei.

Interacting bosons. About ten years ago Herman Feshbach (MIT) and his student, Francesco Iachello, attempted to construct a boson model by considering particle-hole pairs, and more generally, quasi-particle pairs. It was applied to a closed-shell nucleus, and thus in that case emphasized excitations across major shells instead of within a shell. Because these particle-hole excitations were across major shells, they had negative parity. Feshbach and Iachello found some difficulties in constructing a boson Hamiltonian.

In 1974 Iachello (now at the University of Groningen and soon to be at Yale University) decided to attempt an approach similar to that used with Feshbach, but