Book Reviews

Biotic Survivors

Evolution of Hydrothermal Ecosystems on Earth (and Mars?). GREGORY R. BOCK and JAMIE A. GOODE, Eds. Wiley, New York, 1996. xii, 334 pp., illus. $84.95 or £55. ISBN 0-471-96509-x. Ciba Foundation Symposium 202. From a symposium, London, Jan. 1996.

Does history repeat itself? When A. I. Oparin formulated the idea of chemical evolution 70 years ago, others were discussing the possibilities of panspermia, the contribution of comets to the primitive terrestrial environment, and R. B. Harvey's 1924 suggestion that it all began in hot springs with heterotrophic thermophiles. As shown by this volume, the carefully edited proceedings of a meeting chaired by Malcolm R. Walter, we are still debating whether life arrived on Earth from another planet, whether it was periodically destroyed (or fed) by meteorites and comets, and whether it began in hydrothermal vents or under the milder conditions of a Darwinian warm pond.

Fifteen years ago the possibility that life could exist at temperatures above the boiling point of water would have been rapidly dismissed. As Karl O. Stetter writes in his excellent opening chapter, today over 50 different hyperthermophilic prokaryotes are known, most of them anaerobic chemolithoautotrophic Archaea thriving under the harsh conditions of hydrothermal ecosystems. Owing to their unique ability to survive undamaged for several years at ambient temperatures, these microbes have a cosmopolitan distribution: they have been isolated from shallow marine vents, deep-sea hydrothermal vents, and continental hot springs as well as from smoldering coal refuse piles and hot outflows from nuclear power plants.

Although there is some healthy dissent, most agree that the hyperthermophilic Archaea occupy the shortest and deepest branches in ribosomal-RNA–based trees and may thus be some of the oldest organisms still around. It has been argued that their antiquity points toward a hot origin of life, a backward extrapolation of their growth temperatures into prebiotic times that underlies many (but not all) of the papers and discussions included in this volume. Perhaps life appeared in deep-sea vents—but if it did, it could not have involved purines, pyrimidines, and other biochemical compounds with which we are familiar, since there is sound experimental evidence that under such conditions the chemical stability and half-lives of these molecules are greatly reduced.

An alternative possibility is that hyperthermophiles are located near the root of the universal tree because they were the sole survivors of the late-accretion bombardment that boiled the oceans some time after Earth was formed. But as B. M. Jakosky notes, "the uncertainties in the impact rate are such, that the impacts can die off early enough so you can still form life in whatever type of environment you want, without forcing it through the hyperthermophiles." In any case, heat-loving microbes have probably been associated with extreme environments for several billion years, and one of the most provocative parts of this book includes papers on the paleobiological significance of ancient hydrothermal ecosystems. A dozen such sites are known in the geological record, the oldest being Scotland's merely 400-million-year-old Rhynie chert. However, these environments have existed on our planet for at least four billion years, and they hold a wealth of largely unexplored fossil information that may go back to early Archaean times.

This book was already in press when the announcement (recognized in a note added in proof) that the Allan Hills 84001 meteorite may include traces of ancient Martian life sparked several controversies, including the slim possibility that organisms have been transferred between planets. The search for life on Mars is based on the likelihood that its primitive environment resembled that of the early Earth. As M. H. Carr and others write, this included moderate temperatures and liquid water, which may have produced the widely occurring fluvial channels. Subsurface heating of the Martian groundwater by impacts and volcanoes probably led to thermal spring activity, which could be recognized by chemical signatures that are detectable by remote sensing. Vestiges of bygone biospheres may still exist in these deposits, but their identification will require multiple lines of investigation, including diagnostic morphologies and the use of reliable biomarkers. Central to this quest is the view that life is the evolutionary outcome of a chemical process so common, perhaps even unavoidable, that it may be continuously taking place throughout the universe. In spite of their similarities, however, the terrestrial and Martian environments were not completely identical, and Earth may have been the only planet in the solar system ever to harbor life. Hence the question mark in this book's title. One should always keep in mind Pascal's concern about the course of history had Cleopatra's nose been different.

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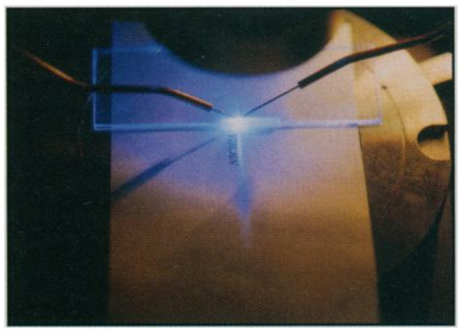
Advances from Japan

The Blue Laser Diode. GaN Based Light Emitters and Lasers. SHUJI NAKAMURA and GERHARD FASOL. Springer-Verlag, New York, 1997. xvi, 343 pp., illus. $69.96 or DM 98. ISBN 3-540-61590-3.

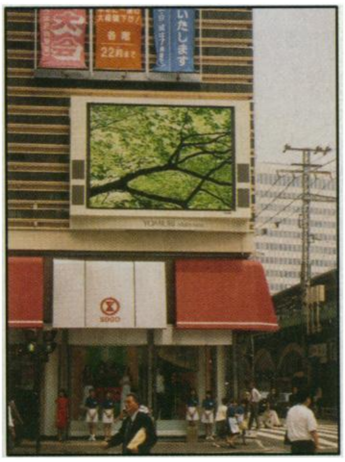
In the past decade several research groups in Japan, particularly those led by Isamu Akasaki at Meijo University and Shoji Nakamura at Nichia Chemical Industries, have reported bright, high-efficiency violet, blue, and green light-emitting diodes (LEDs) made from group III (Al, Ga, In) nitride p-n junctions and heterojunctions.



"The streak line of the laser emission from a LD chip which was operated under pulsed current injection of 1.4 A at room temperature." [From *The Blue Laser Diode*]

In the early '90s Nakamura successfully introduced GaInN quantum wells into the technology and substantially increased efficiency and brightness, and Nichia quickly began selling these diodes. Today, Nichia and Matsushita offer LEDs for sale (in the case of Nichia in the color range from green to blue with quantum efficiencies of about 5%, at prices as low as $1.25 per diode in large quantities; Matsushita gets its diodes from Toyoda Gosei, with which Akasaki was working). Late in 1995, the Nakamura group reported the achievement of laser diodes (LDs), which at this writing have lifetimes of several tens of hours. This is short by a factor of 100 or more of being useful for most applications, but recently progress in nitride light emission has been remarkably rapid. These accomplishments have major implications for such diverse applications as traffic lights, general illumination (since white light can be obtained), large high-resolution flat-panel and projection displays, high-density storage of information, and even energy conservation.

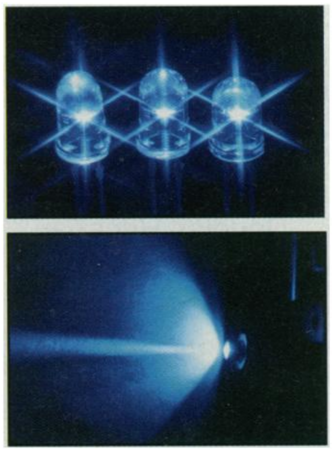
It is amazing that Nakamura's group in particular, and the laboratories in Japan in general, have managed to maintain a substantial lead over scientists and engineers in the rest of the world. This is in marked contrast to earlier major achievements in this field such as the invention of the semiconductor p-n junction laser itself in 1962, when several U.S. laboratories (this reviewer was the lead researcher at IBM on that project) made initial observations within days or weeks of one another that were followed in the next several years by reports of related results from around the world.



Light-emitting diode full-color display. The blue and green LEDs are InGaN single-quantum-well LEDs; only the red are GaAlAs LEDs. [Courtesy S. Nakamura]

The recent startling results from Japan did not come out of the blue, as it were. Efforts in the field go back at least to 1970 when Jacques Pankove, H. P. Maruska, and others at RCA in the United States obtained blue light from a metal-insulator-semiconductor GaN structure. Akasaki, H. Amano, K. Hiramatsu, Nakamura (who is actually a relative newcomer to the field), and others in Japan worked diligently throughout the 1980s and early '90s developing the requisite materials technology for group III nitrides and their alloys, while these materials were largely ignored in the rest of the world. In the United States Mike Haase and co-workers at 3M in 1991 reported blue-green LDs made from group II-VI compound semiconductors, and Bob Gunshor's group at Purdue University and Arto Nurmikko's group at Brown University have made substantial contributions to these devices. However, though at present the lifetime of the II-VI LDs devices is comparable to or even greater than that of the nitride LDs, the II-VI materials are not very robust, and substantial further progress with them thus appears improbable.

Japan's lead over the United States in light emission in the nitrides, which has persisted for almost a decade, is a testimonial to the value of sustained materials science research and to the sophistication of the technology—it is just not easy to play catch-up in semiconductor light emission any more.



Top, Blue light-emitting diodes. [Courtesy S. Nakamura] *Bottom*, InGaN multi-quantum-well structure violet laser diode operated under a pulsed current at room temperature. [From *The Blue Laser Diode*]

The Blue Laser Diode, which offers an account of the work at Nichia, was authored by Nakamura and Gerhard Fasol, a scientist also working in Japan. The first two chapters give some history and tell us that Nobuo Ogawa, the chief executive officer of Nichia, put unprecedented resources, 1.5% of annual sales, into Nakamura's research. Ogawa is to be commended for that and Nakamura for having the guts to take the resources and do something worthwhile with them. The book describes, sketchily, Nakamura's crystal growth system. It gives the physical and optoelectronic properties of the nitrides. It next gives results for p-n junction and heterojunction LEDs. Then it details the structure and optoelectronic properties of the first LDs and the "long"-lived ones. Finally, it gives some speculations about quantum dot lasers.

The book will be of value mainly to students and practitioners working with the group III nitrides, for whom it will be a source of much useful information. It claims to be a lot more, namely "a manual to fabricate blue light emitting diodes"; an explanation of the details behind the "amazing success story" of the development of the GaN-based LEDs and LDs; "a case study of successful research" for use in research management; and a source for scientists and engineers "to start a career in the III-V nitrides." In these respects it falls short for a variety of reasons. It is virtually impossible to transfer a technology by means of a book; it is hard enough to do it by transferring people between laboratories. As a guide to management more generally, the book seems naïve: the real problems are how you find a guy like Nakamura and know it when you have done so. Not the least trouble with the book is that the editing is poor—for example, the references are cited out of order in the early part of the book, and long passages, including tables are needlessly repeated verbatim—so that the book is difficult to use. It is to be hoped that the editing will be better in the second edition, on which the authors are already working, according to the Web page for the book (www.euro-technology.com/bluelaserbook.html). In the meantime the shortcomings of the present edition are more than offset by its timeliness. Overall, it is a very useful, stimulating, and at times amusing book for those working in or close to the large–band-gap semiconductor field.

(The reviewer acknowledges helpful discussions with Hadis Morkoc concerning the history of blue and green light emission.)

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Reprints of Books Previously Reviewed

Blondes in Venetian Paintings, the Nine-Banded Armadillo, and Other Essays in Biochemistry. Konrad Bloch. Yale University Press, New Haven, CT, 1997. Paper, $16. ISBN 0-300-07055-1. *Reviewed* **273**, 1672 (1996).

The Demon-Haunted World. Science as a Candle in the Dark. Carl Sagan. Ballantine, New York, 1997. Paper, $14 or C$19.50. ISBN 0-345-40946-9. *Reviewed* **273**, 442 (1996).

The End of Science. Facing the Limits of Knowledge in the Twilight of the Scientific Age. John Horgan. Broadway Books (Bantam Doubleday Dell), New York, 1997. Paper, $15 or C$19.95. ISBN 0-533-06174-7. *Reviewed* **272**, 1594 (1996).

Lise Meitner. A Life in Physics. Ruth Lewin Sime. University of California Press, Berkeley, 1997. Paper, $16.95. ISBN 0-520-20860-9. *Reviewed* **272**, 42 (1996).

Margaret Mead and the Heretic. The Making and Unmaking of an Anthropological Myth. Derek Freeman. Penguin, New York, 1997. Paper, $12.95 or £7.99. ISBN 0-14-026152-4. Originally titled *Margaret Mead and Samoa*. *Reviewed* **220**, 829 (1983).