Book Reviews

Materials Research—The Birth of a Science

Advancing Materials Research. Edited by *P. A. Psaras* and *H. D. Langford* (on behalf of the National Academy of Engineering and the National Academy of Sciences). National Academy Press, Washington, D.C., 1987. xvi, 391 pp., bound, $ 47.50.—ISBN 0-309-03697-6

The book is based on presentations and discussions from a symposium held in Washington, D.C., on 28-29 October 1985 under the same heading, celebrating the twenty-fifth anniversary of the "Materials Research Laboratories". These laboratories were and are active in selected areas of materials science and engineering--"polymers, ceramics, metals, catalysis, crystallography, mechanical and microstructural properties of materials, artificially structured materials, electronic and magnetic materials, materials chemistry and surface science, solid state physics, and materials processing", to quote the preface of *T. H. Geballe*, Center for Materials Research, Stanford University, and *D. White*, Laboratory for Research on the Structure of Matter, University of Pennsylvania.

The historical aspects of this very successful chapter of the US funding system can only be appreciated by a true insider of the system—to which the author of this review does not belong. The scientific impact of this funding program, however, and the perspectives which arise after 25 years are of more general importance and point to a competitive future, in which the United States, Japan, and Europe will seek to cover research fields which are considered vital for their economies. The US program was initiated by President *Eisenhower* in 1960, some time after the launch of Sputnik I, on 4 October 1957.

What started in 1960 in three "Interdisciplinary Laboratories" (IDLs, to quote one of the book's many, many abbreviations and acronyms) has grown into a funding scheme which now includes about 15 IDLs and MRLs (Materials Research Laboratories). The first three laboratories were at Cornell, Pennsylvania State, and Northwestern universities; eight laboratories followed in 1961 and six between 1962 and 1982. The funding of the different materials science subdisciplines has certainly changed over the years: Metallurgy, which had originally obtained 31% of the resources, is now funded on a 17% level; the so-called "Materials" showed an almost fivefold increase in funding during the same period (from 11% to 51%). This field of "Materials" will be the main subject of this essay.

Although the book contains a lot of basics in materials science, it does not follow the pattern of a textbook, but rather reflects views of the symposium participants on various basic aspects of materials science. The field is truly interdisciplinary; the book summarizes research projects, most of which were physics (35%) and chemistry related (25%) in 1970, until by 1985 materials science (35%) had caught up with physics (35%), and had left chemistry behind (17%), at least in numbers.

In a list of accomplishments we read on page 44:
- Organic Metals
- Ultralow Temperatures
- Lower-Dimensionality Materials
- Surfaces and Interfaces
- Phase Transitions and
- New Materials

No doubt there would be a different emphasis two years after the discovery of a high-temperature superconductor in a European Laboratory of a US company: Neither organic metals nor ultralow temperatures nor 1-dimensionality was the solution to the dream of high-T_c superconductors—to our surprise (speaking for most of us).

After the historical perspective of materials research has been dealt with in the three articles of part one of the book, a report on "Progress and Prospects in Metallurgical Research" opens the second part. This contribution shows that research in metals is more than a race to increase *Young*'s modulus by investigating sophisticated alloys and by freezing-in non-equilibrium systems, etc.; the article points out that metal alloys play a dominant role as silicides in MOS semiconductor devices, as metallic glasses in power transformers (extrapolated savings of $ 0.7 billion per year), and as magneto-optical layers for optical memories. The second article gives a review of the fundamentals of dislocation theory and of the understanding of the ductile properties of metals. The third article reflects mainly those aspects of metals which are appealing to physicists: Heavy electrons (up to 1000 m_e), quantized *Hall* effect and quantum interference effects in superconducting metals.

In crystallography the advent of quasi-periodic structures with 8-, 10-, and 22-fold diffraction rotation axes has given rise to new excitement in a world where the mathematical boundary conditions of space filling and infinite crystals have so long prevailed.

The short article on "New and Artificially Structured Electronic and Magnetic Materials" covers the field from superionic conductors to quantum well semiconductors, with only brief discussions of the organic 1-dimensional conductors and conducting polymers which have kept many theorists and experimentalists busy after *A. Heeger*'s work on TTF-TCNQ in 1973. I am sure that a similar book in 25 years would feature several articles with headings similar to the one of this chapter.

The article on catalysis is short and emphasizes the EXAFS method, leaving out many aspects of metal-substrate interactions and modern analytical surface characterization tools, e.g., electron spectroscopy and imaging.

The question of "The Role of Chemistry in Materials Science" is treated more like a survey over various topics (new polymers, interface-modifying agents, ..., self assembling systems). It is followed by a short review on "Advanced Ceramics"--too short considering the relevance of these materials. The article on "Organic Polymers" is also very didactically styled. Questions like: How does a very long 'snake-like' molecule diffuse? are treated in enough detail to be understandable.

The last article of the second part, "New Ways of Looking at Surfaces", is more a short presentation of methods and recent applications avoiding details, which would be valuable for the technically interested reader.

The last and shortest part of the book, "Current Topics in Materials Research", reports on facilities and instrumentation, and may therefore be important for people interested in funding practices and politics.

In spite of its inhomogeneous character, with detailed articles describing dislocation theories of metals or the reptation model of polymer diffusion on the one hand, and articles which only give keywords without further explanation on the other hand, the book serves its purpose: It gives a rather complete summary over the first funding period of a gigantic and successful program and it sketches important challenges. Maybe the international competitiveness of today's research in materials science is responsible for the fact that extremely topical research areas such as impact-resistant ceramics, quantum wells, and new aspects of semiconductor research, are only touched upon briefly.

There is no equivalent European or Japanese book on the same topic. The book reflects a good American tradition of formulating and reviewing national goals. I hope that some European programs are stimulating and powerful enough to be the basis for a rewarding book 25 years from now.

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Biosensors

Biosensors International Workshop 1987 (GBF Monographs, Vol. 10). Edited by *R. D. Schmid*. VCH Verlagsgesellschaft, Weinheim 1987, XIV, 346 pp, paperback, DM 128.00, ISBN 3-527-26801-4

In June 1987 the "Gesellschaft für Biotechnologische Forschung (GBF)" invited a representative circle of speakers to a workshop on biosensors in Braunschweig (FRG). The conference proceedings, published late in 1987, offer a good survey of the great variety of lectures held at the GBF. These topical proceedings illustrate, with a well suited mixture of reviews and reports, the broad range of biosensor research as well as the innovative power and the state of the art of this technology.

One of the purposes of this workshop was to define the position of the West German biosensor research in comparison with international activities in the field. In the preface the editor comments on the current situation and describes the position of the FRG by way of analyzing statistical data about biosensor publications and patents. Based on data from 1985, the West German biosensor research has to be placed in the sixth rank, far behind the dominating Japan and even behind the GDR.

Brilliant examples of new biosensors that make use of all important transducer technologies (potentiometric, amperometric, fiber optic and piezoelectric) were presented and their enormous potential, especially in medicine, was illustrated with ion-, enzyme-, and immunosensors. In addition, possible applications of biosensors in process engineering and environmental protection were discussed.

The performance of biosensors is already impressive. Gas sensors for organophophorus compounds with ppb sensitivities and immunosensors with detection limits beyond the picomolar range were reported. The large number of lectures about glucose sensors gives an impression of the topicality and importance of this subject. The long-term goal is an implantable glucose sensor which, combined with an insulin pump, would improve the life of many diabetics. In general, most of the biosensors are developed as diagnostic tools. Because of their excellent performance and cost effectiveness they have already become serious competitors to established methods. Remarkable success in this field is reported from the GDR.

There are many different approaches to reach the long-term goals, i.e., the combination of smale size (mm scale), cheapness (less than 50 cents), high sensitivity (nM–μM) and selectivity (10^5 or better), longevity (years), and high reliability (margin of error less than 1%) in one biosensor. The capabilities of living systems serve as a model. The detection sensitivities of sea animals to minimal water contaminations (down to 10^{-13} M) that are used, for example, to control the quality of drinking-water are still unrivalled. Biosensors with natural receptors are the way to imitate nature in this respect.

The efficient interdisciplinary cooperation of different fields like biology, chemistry, electronics, physics, and medicine is an important key to success and characterizes the internationally leading groups. It should be mentioned that there were also a few interesting contributions from West German researchers, and they demonstrated that a variety of innovations in this field are awaiting a breakthrough. The question remains why biosensor research, which will be an important economic factor in the next decades, has been so long neglected in the FRG. It is estimated that the nineties will see the commercial breakthrough of biosensors. For the year 2000 a study predicts an American biosensor market of $ 200 million for medical applications alone. Biosensors are also important for biotechnology, environmental technology, and the food industry. However, the proceedings of this workshop leave no doubt that medical applications predominate. The current situation in biosensor research in West Germany bears some similarities to the status of microelectronics and gene technology research a few years ago; in both fields, the FRG is now having to undertake enormous efforts to reach international standards. Will biosensor research have a similar fate? Immediate strong support for this interdisciplinary field could help prevent this.

A final word on the workshop proceedings: The editor should have insisted on a better elaboration of some of the abstracts. In a few cases a half-page summary of a lecture is all that is provided. However, the book enables one to rapidly obtain a comprehensive overview of the state of the art in biosensor research. Also, the book gives an impression of the innovative power of this technology.

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