Large amplitude vibrations in molecules

Internal Rotation and Inversion: An Introduction to Large Amplitude Motions in Molecules. By D. G. Lister, J. N. Macdonald and N. L. Owen. Pp.246. (Academic: London and New York, 1978.) £11.50.

LARGE amplitude low frequency vibrations comprise a somewhat specialised topic within the subject of molecular vibration–rotation spectroscopy. However, they comprise a topic of particular interest for a number of reasons and are thus a deserving subject for a specialist text. The interest arises because these vibrations represent motions along the valleys in the molecular potential energy surface, so that they are of especial interest in the molecular dynamics of conformational changes and chemical reactions. Also, the experimental data on the energy levels of low frequency vibrations may be extensive (in contrast to the usual situation for other vibrations), and the theory by which they are related to the potential energy surface does not fall into the usual pattern of vibrational theory. Thus, in principle a book on this subject might be of interest to a wide range of chemical physicists.

This book starts with an introductory chapter on the concept of large amplitude vibrations, with many examples, and diagrams of sections of potential energy surfaces. Chapter 2 deals with basic theory, chapter 3 gives a cursory account of experimental methods (microwave, infrared, Raman and NMR spectroscopy, and electron diffraction), chapter 4 reviews *ab initio* and semi-empirical potential surface calculations, and the remaining five chapters discuss particular examples of large amplitude vibration in more detail—essentially internal rotation, inversion and ring puckering vibrations, and conformational motions in macromolecules.

Although the physical ideas are well presented, the authors have attempted to write a book which is not too taxing in mathematical theory and quantum mechanics. Sympathetic as I am to this ambition, the serious student has to face up to the theory, for indeed the relationship of experimental spectra to potential surface should be the unifying theme of the subject. Thus, I found the book weak in the very area where I feel it should be strong. The theory is loose where the student wants rigour; the material is badly organised; some important topics are not mentioned and others are discussed twice in different places without any apparent correlation. As examples of these defects: on p23 "transpose" should read "conjugate transpose"; equation (2.45) on p42 lacks a factor $h^2/2I$; different methods of solving the Mathieu equation are discussed on p42 and p111 without any cross reference or comments to help the reader; and the effects of inversion on rotational constants are also discussed twice, on p58 and p70, again without cross reference (why is a first power term in x included on p70 and not on p58?), although one might reasonably have expected to find this discussion in chapter 7 or chapter 8. Many passages give me the impression that they will be of little help to a student who does not already know the subject, and of even less help to the student who does; as examples of this, consider the page about Van Vleck transformations (p25–26), or the four pages about gas electron diffraction (p81–84). The important topic of the symmetry of non-rigid molecules, developed in the past ten years by Longuet-Higgens, Hougen, Bunker, and others, does not seem to be mentioned anywhere in the book. Quasi-linear molecules are an important class of molecules with large-amplitude vibration that are not discussed.

The book has its good points; one of them is indeed the subject itself! But in today's sophisticated and competitive world of specialist scientific textbooks, I feel that it has not been written with the care and attention to detail that are necessary for success.

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Thin films and the electronics industry

Thin Films: Interdiffusion and Reactions. Edited by J. M. Poate, K. N. Tu and J. W. Mayer. Pp.578. (Wiley: New York and Chichester, UK, 1978.) £25.

MANY reasons are advanced to explain why our scientific and inventive abilities in the physical sciences are frequently not realised in industry. One good reason is the failure by scientists and industry alike to treat product design and manufacturing processes as vital technologies which must develop their own specialised sciences if inventiveness is to be fulfilled in the market. We all know, without effect, that this common neglect stems from our history when science developed rapidly and modern industry was founded, both occurring almost independently. This unsatisfactory division rooted in the scientist of independent means and the practical manufacturer has lead to the notions that the study of how one makes things and how they perform is too close to common work to be regarded as suitable activities for trained minds; and in any case such investment is wasteful. Only during the last War did scientists effectively join with industry to develop expertise; but so quickly did we slip back that we now seem to have no defence against another crisis—that of market competition.

If one doubts the validity of these comments then it is only necessary to read recent views of the decision of the National Enterprise Board to enter the microprocessor field. Expert opinion on this relates to financial investment problems, preference for licencing overseas know-how, industrial need for microprocessors regardless of dependence on supply, and the novelty of the electronics and their social effects. Nowhere have I found any mention of what must be done to found a satisfactory industry in the UK for the manufacture of large scale integrated electronics. For example, who supplies the process plant? A new area of electronics cannot be established without the association of scientists and engineers developing production and product know-how and training skilled workers, that is, if the enterprise is to be more than a manufacturing unit with off-shore control of every aspect of its activities.

The book under review dealing with problems encountered in making and operating solid-state devices illustrates what must be done to establish such an industry. It also shows how US companies are able to create the industrial science needed for the purpose at hand. There remarks are not intended to be disparaging of the work done by R & D scientists in solid-state laboratories in the UK but to point up the effects of inadequate R&D funding in an industry which once enjoyed a position next to the US in the world league.

The book's editors have experience of the subjects treated from research in their laboratories. Dr Poate, a one-time Harwell Fellow, is now with Bell Laboratories; Dr Tu is a specialist in solid-state diffusion at the IBM Thomas J. Watson Research Center; and Professor Mayer is concerned with ion/atom collision effects at the California Institute of Technology. Their contributions are supplemented by others from research colleagues and members

of the laboratories of Sandia and Philips (Amsterdam). These authors have related the thermal, chemical and electrical effects occurring in semiconducting devices to the materials and growth processes used in their fabrication. There are chapters on metal/metal interdiffusion, electromigration in thin films, electrode/compound substrate reactions, depth analysis and thin film deposition.

I read the chapters on atom transport and chemical reactions with interest because of their topical nature and because I was least well acquainted with their subjects. A new micrometallurgy is introduced in which the conditions for grain boundary diffusion, intermetallic and silicide formation and electromigration in a variety of film materials is treated over depth and surface dimensions of a fraction of a micrometer. As is essential in a book of this kind the text is well illustrated with micrographs.

I did not expect a detailed description of deposition techniques but a balanced and informed account of those in common use. Thus I question the wisdom of referring to ion beam deposition as a promising new technique while omitting mention of plasma chemical procedures which seem to have an important future in silicon technology. Also the reader is not informed that ion beam deposition is only possible when the self-sputtering yield of the incident ions is below one. Further, without experimental evidence it is unsatisfactory to suggest that ion bombardment may aid epitaxy; the case cited of poolycrystalline carbon is for deposition on a non-crystalline substrate. Generally, ion impact results in damage.

Sputtering is listed under collected deposition techniques as having the disadvantages of causing substrate damage and heating. Mention could have been made of sputtering apparatus with crossed electric-magnetic fields (magnetron) to deflect electrons from the substrate and reduce heating. It is an over simplification to lump together under "damage" particle and radiation effects which have different sources and intensities in sputtering plant operating from 10^{-3} to 10^{-1} torr gas pressure. The treatment of mixed component sputtering is not consistent. In the discussion of depth analysis (p149) it is said correctly that after an induction period components are released at rates proportional to their bulk contents, but on p95 it is stated that this only happens if there is no preferential sputtering to change the target surface composition. Few mixtures can have sputtering yields directly proportional to their contents but preferential sputtering raises the surface content of the less favoured component thereby aiding the latter's emission. As the emission of a component is proportional to the product of its surface content and sputtering yield, an equilibrium is reached under which the emission ratio is equal to the component ratio of the bulk material.

It is always dangerous to refer to a reference by way of another (in this case Chopra for Gillam) as on p95 when discussing the enriched Au layer formed on $AuCu_3$ alloy during Ar sputtering. The enriched layer is stable and results in component emission with the bulk contents ratio and not that of the enriched layer as stated on p95.

The above criticisms are of subsidiary material and they do not detract from the value of the main text in dealing with the behaviour of metal/semiconductor systems. As a reference work it will be of value to those who want to obtain a comprehensive picture of operational problems in solid-state electronics and also those who are entering the field to produce electronic devices. The authors and the Electrochemical Society (who supported the work) are to be commended for recognising its need and for its useful preparation.

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Asiatic ungulates

Mountain Monarchs: Wild Sheep and Goats of the Himalaya. By George B. Schaller. Pp. 425. (Chicago University Press: Chicago and London, 1978.) £17.50.

THIS book, the latest in the generally excellent Chicago University Press series on wildlife behaviour and ecology, reports the results of three years of field work with the large mammals of the Himalayas, with emphasis on the wild sheep and goats of the region. The work will undoubtedly stand as the foremost source of information on these Asiatic ungulates for many years. One short chapter describes observations of the large carnivores of the region.

The book is generally organised into chapters dealing with broad biological topics such as distribution, physical attributes, herd dynamics and courtship behaviour. In each chapter, the array of species is treated according to the level of information available. Narrative or tabular summaries of the biological attributes of each species are generally lacking. This fragmented mode of presentation makes the work less readable than other books in the same series. The organisation of the book, together with its enormous geographical scope and the unevenness of information on various species, makes reading frustrating and confusing at times. Nevertheless, the author is to be commended for putting together in one volume the results of years of fieldwork under incredibly difficult conditions and an exhaustive review of the relevant literature, scanty though the latter is. Fortunately, the index is reasonably complete, although it cannot be depended upon to ferret out every piece of information, nor is it very helpful in dealing with the vast and confusing array of place-names.

The author concentrated his fieldwork on three species in Pakistan, Nepal and India: urial (*Ovis orientalis*), wild goat (*Capra aegagrus*) and bharal or blue sheep (*Pseudois nayaur*). The information on bharal is probably the most valuable and interesting. This little-known species possesses a complex mixture of sheep-like and goat-like behavioural and morphological characteristics. Schaller concludes (p44) that, "In general, bharal are considered aberrant goats, with sheep-like affinities". Again, however, the reader must refer to many pages of text, scattered throughout the book, to construct a cohesive picture of the biology of this species.

A concluding chapter on the evolution of the Caprinae provides a new perspective on this topic based on the author's own data on Asiatic caprids and literature review. This discussion of evolution and dispersal presents some counterpoints and alternative hypotheses to those of V. Geist (*Mountain Sheep*, Chicago University Press, 1971). Taken together, the two books provide a provocative basis for further research. However, as the author makes abundantly clear in his concluding remarks on the conservation of the Himalayan fauna, time is running out. Many species have been fragmented into small isolated populations, occupying habitats drastically altered by man. The reader is left with the clear impression that even the best system of reserves in the Himalayas will be inadequate unless broad changes in land-use practices can be instituted. In this regard, the enormity of the problems, economic, ecological and political, to be faced is evident.

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