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Book Reviews

Gmelin Handbook of Inorganic and Organometallic Chemistry: 8th Edition. Silicon Supplement Volumes B 5d1 and 5d2. Edited by F. A. Schröder. Silicon Nitride: Electrochemical Behavior and Chemical Reactions. Springer Verlag, Berlin, 1995. 255 + xiii pages (ISBN 3-540-93711-0) and 303 + xiii pages (ISBN 3-540-93716-1).

These two latest Gmelin Handbook Silicon Supplement volumes, which form part of a series covering silicon nitride, provide an important guide to the literature on this material. The Gmelin Handbook, produced in Frankfurt by the Gmelin Institute for Inorganic Chemistry of the Max Planck Society for the Advancement of Science, is well known to inorganic chemists, for whom it provides a quick and reliable source of information on the physical and chemical properties of the elements and their inorganic and organometallic compounds. For workers in other fields the Handbook perhaps needs a few words of introduction.

The first Gmelin Handbook, a set of three volumes, was published by Leopold Gmelin in 1817. The Gmelin Institute in its present form was founded in 1948. Earlier volumes of the present 8th Edition were in German with English subheadings, but since 1980 they have been entirely in English. The complete Gmelin Handbook, now running to a total of some 740 volumes dealing with all the elements, provides in an organised way factual information gathered primarily (though not exclusively) through systematic reading of the world literature covered by the Chemical Abstracts series of the American Chemical Society. In practice this means that all research papers of significance appearing in internationally recognised journals and conference proceedings, as well as other forms of scientific output such as patents and research reports, dealing with the chemical and related sciences are covered. Review papers and books are also included. Information is extracted from those publications identified as 'critical' (a great many publications simply re-present previously published information), normally using the original documents (or in extreme circumstances the abstracts) by teams of authors supervised by scientific editors, and presented as a set of succinct, factual summaries. It is compiled using a structured and formalised style, which permits the reader simultaneously to obtain a discreet assessment of its probable reliability. All information, supported as necessary by graphs and diagrams, is fully referenced and where helpful is cross-referenced. This task clearly requires each team member to be capable of making objective and critical assessments, and members are picked for their scientific experience, maturity and judgment. These volumes do not constitute literature reviews in the usual sense: the main objectives are to be factual, accurate, detached and concise, and commentary is kept to a minimum.

The Handbook volumes have two major uses: they provide a quick and very detailed reference source of data and factual information about the elements and their inorganic and organometallic compounds; they are also invaluable in the initial stages of a systematic literature search relying on the Chemical Abstracts series, in that they make it unnecessary to work through Chemical Abstracts indices and volumes covering literature prior to the closing date cited in the front of each Handbook volume. The most recent main Handbook volume on silicon, *Silicon and Compounds*, was published in 1959: since then 11 Supplement Volumes have appeared. Previous Supplement Volumes dealing primarily with silicon nitride, B 5c *Silicon Nitride in Microelectronics and Solar Cells*, and B 5e, *Non-Electronic Applications of Silicon Nitride, SiN_x. SiN_x:H*, were published in 1991 and 1994. Two earlier Silicon Supplement Volumes B2 and B3, published in 1984 and 1986, deal comprehensively with silicon carbide: these two volumes contain more than 7000 literature references and are an invaluable source of information on silicon carbide

for all workers with an interest in this area (it is a pity that their existence is not more widely known among the ceramics community). The Gmelin Handbook volumes on silicon nitride, published and planned, extend these facilities to a second important nonoxide technical ceramic: they bring, moreover, a rigour to literature searches on silicon nitride, and an accuracy and objectivity in the treatment of related chemical information, which are not always found in the materials science area.

The literature dealing with silicon nitride provides a major challenge to any person or organization attempting a systematic summary compilation of information. The sheer number of publications dealing with the main nitride of the element silicon, Si_3N_4, is daunting: at the present time (July 1996) there are an estimated 34 200 publications, and the number is growing at the rate of 2000 to 3000 a year. For an organization with a chemical orientation such as the Gmelin Institute the problem is compounded by the fact that, because silicon nitride is not simply a chemical compound but also an engineering material, many of these publications of necessity deal with the important relationships between chemical and technical processing, microstructures, and properties, and the properties of primary interest have in many cases been mechanical. Nonetheless, having embarked on this task, it was judged by the Gmelin Institute to be necessary for the sake of completeness to continue to see it through, and not knowingly to exclude any significant material related to silicon nitride. During this compilation many apparently, or actually, contradictory results and interpretations were detected; like the other information these are generally reported as found, though sometimes with suggestions for their resolution. This is in accord with one of the stated aims of the Handbook volumes: not to attempt to omniscience or support the development of dogma, but where necessary to draw attention to difficulties of interpretation and to try to suggest potentially fruitful lines of further enquiry. The literature on silicon nitride is certainly not lacking in problematic areas and controversy; the further function of the Handbook is to bring into focus their existence and, through objectivity and the breadth of information made available, to assist future workers to advance real knowledge and understanding.

The Silicon Supplement Volumes 5d1 and 5d2 summarize the literature up to December 1992 (though many papers appearing in 1993 and 1994 are also covered) and contain of the order of 2300 references to new experimental work. They deal with the crystalline and amorphous forms of silicon nitride, and the sialon (Si-Al-O-N) solid solutions. The first Supplement volume covers electrochemical and other physical-chemical phenomena, colloidal chemistry and reactions with metals and their nitrides and oxides. The second volume continues from the first, covering chemical reactions treated broadly and including such diverse topics as oxidation chemistry, biochemistry and toxicity. This second volume also includes a comprehensive alphabetical and cross-referenced index of reactants, as well as an invaluable index of Si_3N_4-multicomponent ceramic systems. To see the index to Supplement Volume 5d1 it is therefore necessary to have access to both volumes, although because of the systematic form of presentation and the Table of Contents, an index is not actually essential (Volume 5d1 also contains a summary table of the contents of 5d2).

Supplement Volume 5d1 contains sections on silicon nitride thermal decomposition, the effects of radiation, tribochemical reactions during sliding and wear, and the reactions of silicon nitride with metals, metal nitrides, and metal oxides (including SiO_2). The last section includes treatment of the chemistry of the important Si_3N_4-metal oxide systems commonly used in the densification of silicon nitride by sintering or hot-pressing, though the subject of silicon nitride densification itself will be dealt with in Supplement Volume B 5a2. This section is prefaced with a valuable list of 'Selected Review Papers' many of which, although dealing primarily with the chemical reactions area, now have classical importance as charting the historical development of the subject of silicon nitride ceramics.

Volume 5d2 concludes the treatment of the room and high temperature reactions of silicon nitride. Although it covers oxidation and corrosion and other nonmetal reaction systems in general, it is mainly concerned with the oxidation chemistry of Si_3N_4, and reactions with common environments such as air, water, and combustion atmospheres (including the oxides of carbon and sulphur), and with the halogens under normal and plasma conditions. It considers the reaction of single phase and nominally pure silicon nitride, as well as those involving the complex Si_3N_4-metal oxide systems which represent the sintered or hot-pressed silicon nitride ceramic materials. There are sections on aqueous acid attack (particularly HF) and metal salts as solutions and in the molten state. The concluding short section deals with reactions involving organic compounds, including the important but less well studied thermochemistry of surface adsorption reactions. As in the first volume, there is a valuable introductory overview of the review literature on this subject.

These well written and presented Handbook volumes are essential reading (or at least, skimming)

for any researcher considering working in these branches of the silicon nitride field, and for engineers and scientists planning to use silicon nitride. They save time which would otherwise be spent designing and undertaking personal (even on-line) literature searches; and in a subject area as extensive and as complex as that of silicon nitride this is no small consideration. It is a common complaint about many papers that the authors do not seem to have properly read the international literature. These Gmelin Handbook volumes may be said, up to a point, to have the great merit of making reading this literature unnecessary, in that the recent literature on silicon nitride has been read and digested, and the important chemical information extracted. Provided access to these volumes can be obtained there is now no excuse at all for any author not to be fully conversant with important facts and data, or at least not to be aware of the existence of significant papers. For the scientific literature of the last 3 to 4 years there is unfortunately no short cut and current issues of Chemical Abstracts or other indexing systems, or the journals themselves, must be consulted.

These two new volumes on silicon nitride are very much welcomed, and the Gmelin Institute and its editor Friedrich Schröder are to be congratulated on the outcome of an undertaking of considerable magnitude. The volumes contribute towards providing a detailed and invaluable picture of the present state of knowledge of the underlying basic chemistry of what must be the most thoroughly researched technical ceramic materials of the past 25 years. At the price of just over £1600 for the two volumes there will not be many personal buyers, but it is to be hoped that institute libraries can be encouraged to add them to their Chemistry Sections' Gmelin Handbook volumes.

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Advances in Particulate Materials. By A. Bose, Butterworth-Heinemann, Boston, 1995. ISBN 0-7506-9156-5.

Advances in Particulate Materials is divided, apart from the introductory chapter (50 pages), into five main chapters. The first deals with 'Chemical powder production approaches' (31 pages) while the second deals with 'Melt atomization' (71 pages), followed by chapters on 'Mechanical alloying' (49 pages), 'Intermetallic compounds' (51 pages) and 'Particulate injection moulding' (37 pages). An eight page index concludes the book.

In the introduction a concise overview is given of powder characteristics consolidation techniques and applications. Particularly relevant is a five page section on hazards associated with the use of particulate materials.

The chapter on 'Chemical powder production approaches' deals with various techniques; for example the reduction of oxides, the use of organo-metallic chemistry, powders from salts and by chemical vapour deposition. It is argued at various points that 'lack of proper co-ordination between chemists and powder metallurgists is the only reason why chemical powder processing has not become a tremendous commercial success'. For ceramics one has to add the fact that the price of these powders is also frequently an obstacle. The main emphasis is on metallic powders.

Melt atomization is devoted to processes which use disintegration of liquids into a fine spray of droplets by high-velocity fluids, by centrifugal forces, by vibrational energy or otherwise. Again the main emphasis is metallic powders.

In spite of the long tradition in milling, the fabrication of powders by mechanical alloying is a field in which rapid progress has been made and where new materials have emerged. In ceramics the impact of milling techniques on the size and size distribution is well known but also the influences on chemical reaction is profoundly present. For metals, improved powders and thereby microstructures are obtained. In particular the dispersion of brittle particles in ductile matrices can be considerably enhanced.

The chapter on intermetallic compounds deals more with the properties of this class of materials than with their fabrication. I find this chapter interesting as such but not very well positioned in this book. The final chapter gives a short overview of the process details on injection moulding. The well-known book by German is frequently referenced.

Powder metallurgy in its widest meaning is becoming more and more important in manufacturing industry. The description 'Powder Metallurgy' is misleading since the discipline not only includes metal powders but also ceramic powders. In the introduction of this book a plea is made for changing the meaning of the abbreviation P/M from 'Powder Metallurgy' to 'Particulate Materials'. I fully agree with this suggestion and introducing it in the title may help to disseminate this view. However, only limited attention is given to ceramic powders in spite of the intention expressed in this introductory chapter. This is an important drawback of the book for ceramists. Also, a book entitled 'Advances in . . .' awakens the impression that the latest developments in the state of the art