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Book Reviews

Carbide, Nitride and Boride Materials—Synthesis and Processing. Edited by A. W. Weimar. Published by Chapman & Hall, London, 1997. ISBN 0 412 54060 6. 671 pp.

'Carbide, Nitride and Boride Materials—Synthesis and Processing' gives a comprehensive overview with valuable information for industry, academia as well as newcomers looking for an introduction to the field. This book claims to be the first monograph in the field of non-oxide materials and is written as an organised textbook and not a collection of randomly organised papers.

It is of interest to chemical, mechanical, and ceramic engineers, as well as material scientists within university and industrial environments working with carbides, nitrides and borides.

All chapters are written by leaders in the field, including academic, industrial and government laboratory affiliated authors. The many figures and photographs help the reader to comprehend the material.

The subject matter ranges from materials properties and applications to methods of synthesis including pre and post synthesis processing.

The book consists of nine sections, starting with the 'Introduction' and an overview on the applications and engineering of non-oxide materials, followed by a chapter on critical powder characterisation. In this chapter the characteristics of WC, SiC, Si_3N_4 and AlN are described as well as the influence of sintering additives, oxygen content and particle size distribution on the sintering behaviour.

Section 2 details the 'Carbothermal Reduction Synthesis Process'. In the chapter on thermochemistry and kinetics the importance of the gas phase with respect to the synthesis of carbide and nitride powders is discussed. The following chapters describe in detail the different carbothermal processing routes, for example; the Acheson process, the electric arc furnace process, tube / pusher / moving bed furnaces, rotary tube reactors and fluidized bed reactor processes.

In Section 3 the thermochemistry, kinetics and the principles of the 'Combustion Synthesis Processes' are discussed.

The synthesis of different ceramic materials from gaseous precursors is described in Section 4: 'Gas Phase Synthesis Processes'. The thermal aerosol process as well as laser and plasma reactors are subsequently discussed.

Section 5 deals with the 'Liquid Phase Synthesis Processes' of silicon nitride, boron and aluminium nitride as well as carbides and borides.

The 'Synthesis of Whiskers, Platelets and Fibres' is described in Section 6. The growth mechanisms, growth processes, characterisation and properties of SiC whiskers and platelets are discussed in one chapter. Also the preparation, composition, structure and properties of ceramic fibres derived from polymeric precursors are described. Only fibres which have reached a commercial status are emphasised. New activities in fibre development, such as the Si–B–N–C fibres from Bayer (Germany), the Si–N–O fibres from EMPA (Switzerland) or others are not mentioned.

In Section 7, 'Pre/Post Synthesis Processing', the methods and equipment for size reduction, chemical purification, solids dispersion in liquids and spray drying processes are discussed. This includes ultrafine grinding, removal of carbon, oxygen and metal impurities, the dispersion theory and colloid stability as well as the rheology of non-oxide slips.

Section 8 deals with 'Coatings, Films and Infiltration Processes'. The fundamentals and models for the chemical vapour deposition process (CVD) and the chemical vapour infiltration process (CVI) are described in addition to the chemical kinetics, mass transport and different applications for these processes. In a second chapter the plasma enhanced chemical vapour deposition (PECVD) of non-oxide ceramics is reviewed and the deposition of specific ceramic films is discussed in terms of precursors, types of plasma and film properties. The focus is on non-oxide ceramics used mainly as hard coatings. Applications for microelectronics are not reviewed.

The final section of the book deals with 'Design Considerations for High Temperature Furnaces'. Different process and product considerations, furnace configurations, high temperature heat sources and insulation are described. A separate chapter is dedicated to rotary tube calciners.

Each chapter has up-to-date references up to and including the early part of 1996 and the book contains appendices with valuable information on crystallographic, thermodynamic and thermal properties. The mechanical, electrical and magnetic properties at 293 K as well as the chemical properties of non-oxide materials are also tabulated, making the book a convenient source of reference.

The book will be a valuable resource for everyone interested in advanced ceramic materials.

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Silicon Nitride: Mechanical and Thermal Properties; Diffusion. By Roger Morell and Frank L. Riley. Silicon Supplement Volume B 5bl. Gmelin Handbook of Inorganic and Organometallic Chemistry: 8th Edition. Edited by Friedrich Schröder and Wolfgang Kurtz. Springer–Verlag, Berlin, 1996. ISBN 3 540 93733 1. DM 2500.

Silicon nitride ceramics are one of the most interesting structural materials for replacing metal compounds in high-temperature applications in engines and gas turbines, but they may also be useful for many applications where a high wear resistance is required. The increasing interest in using silicon nitride ceramics as turbocharger rotors, valves, bearings or cutting tools is due to the enormous progress made in recent years in developing high strength materials with high reliability, and excellent thermal shock resistance. These world-wide research activities have produced thus far more than 34 000 publications on silicon nitride and the number is growing at a rate of 2000 to 3000 per year. Therefore, it will be difficult for most researchers to get a quick overview of the available data.

The Gmelin Institute for Inorganic Chemistry, known for its careful and extensive literature search, has summarised the most important information on silicon nitride. Between 1991 and 1995, the Gmelin Institute published four Silicon Supplement Volumes on silicon nitride. The last Supplement Volume B 5b1, dealing with the mechanical and thermal properties as well as the diffusion, has just been released. It is based on the available literature up to December 1992, but also on some proceedings published later. The book totals 415 pages and is divided into nine main sections under the following headings: density, elastic properties, hardness and wear resistance, strength and related properties, plastic deformation, thermal stress and thermal shock resistance, mechanical properties of silicon nitride joints, thermal properties, and diffusion in silicon nitride. Several of these chapters begin with an overview or general remarks, so that also non-experts are able to understand the succeeding results. Each chapter is clearly organized, and the three main types of silicon nitride ceramics, reaction bonded Si_3N_4 (RBSN), sintered Si_3N_4 (SSN), and hot-pressed or hot isostatically pressed Si_3N_4 (HPSN, HIPSN), are discussed separately; basic mechanical properties of CVD-Si_3N_4 are also given.

The first part of the Handbook presents basic physical and thermomechanical data of the various silicon nitride materials, followed by an overview of hardness and wear resistance measurements; the thermal properties are covered in a separate chapter. These basic data on Si_3N_4 ceramics are a very helpful guide for engineers who design silicon nitride components. The chapter 'Wear and Friction Properties' is relatively short compared to others, although these properties are important for many applications. The main topic, 'Strength and Related Properties', covers 212 pages and describes in detail the short-term and long-term behaviour of silicon nitride ceramics. It considers the influence of additives, processing conditions as well as the microstructure on the mechanical properties, but also discusses strategies for improving the strength and fracture toughness. However, since most of the literature is older than 5 years, most of the recently published and fundamental results concerning the influence of the grain boundary chemistry and the effect of grain size and morphology on toughness and strength are not included. These aspects are expected to be included in a forthcoming Gmelin Handbook article on the microstructure. Additional information is given on the effect of environmental conditions on the degradation of the mechanical properties. Also covered are fractography, non-destructive flaw detection, and the reliability of silicon nitride products. The analysis of the thermal stress and thermal shock resistance not only covers Si_3N_4 bulk ceramics, but also thin films and coatings. The section on joints contains very useful results of the different methods to realize joints between Si_3N_4 and other materials. Measurements of the self diffusion and the heterodiffusion of hydrogen, metals, and non-metals are presented at the end of the book.

The authors, Roger Morell and Frank L. Riley, both well known in the ceramic community, and Joachim Wagner of the Gmelin Institute have done a great job in extracting the important data on the mechanical properties from a huge number of publications. There is no doubt that this volume provides the best available summary of the last three decades of silicon nitride research. Many scientists and engineers, especially those who start to work with Si_3N_4 ceramics can save a lot of time by using this well-prepared Handbook volume. Therefore, technical libraries should be encouraged to buy this volume despite the relatively high price of DM 2500.

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