or $r < -0.6$, they are statistically judged to have a significant correlation'. The statistical significance of correlation depends on the number of observations and there is no reference to this. So technically the statement is wrong.

There are other anomalies too. The authors repeatedly refer to papers in Japanese, which are unlikely to be accessible to readers. Another anomaly is the frequent absence of formulae. If the material is for users of statistics, this lapse can be fatal.

Amazon.com quotes a price of US$ 45.00. For a person or library with limited funds, it may be better to skip this one.

SHARAYU PARANJAPE

Department of Statistics,
University of Pune,
Pune 411 007, India
e-mail: saparanj@stats.unipune.ernet.in

Materials Research: Current Scenario and Future Projections. R. Chidambaram and S. Banerjee. Allied Publishers Pvt Ltd, New Delhi. 2003. 679 pp. Price not mentioned.

The last few decades of the twentieth century have witnessed a revolution in the development of tailored materials, with a profound impact on advances in technology development in nuclear energy, space, aeronautics, defence, electronics, photonics and information technology. In each of these sectors, progress has been possible due to the development of new materials.

It is well established that the availability of suitable materials is the fundamental requisite for the development of the advanced technologies. The book under review consists of 31 review articles contributed by authors representing a large number of academic and research institutions in India, and covers a wide range of materials, including liquid crystals, aerogels, superalloys, shape memory alloys, refractory metals, rare earths, metal matrix composites, compound semiconductors, ceramics and carbon-based materials. Most of the articles address the basic principles behind the relevant phenomena, different aspects of materials processing and characterization and the applications of these specialized materials. The purpose of this book is to bring out the developments that have taken place over the last few decades in the domain of materials science, processing and related technologies in India against the background of the current global scenario and provide directions for future research.

The article entitled 'Materials research and technology foresight' by R. Chidambaram addresses the current trends in materials research with special emphasis on technology foresight. Chidambaram has clearly defined the role of basic and applied research in development priorities of the country. In his opinion, basic research should be globally competitive, while applied research and technology should relate to the demands of national development and security of a country. Chidambaram has categorized the current trends in materials research as miniaturization, mimicking nature, processing in conditions far from equilibrium, and predicting and tailoring structure and properties of materials by computational techniques.

In space missions, materials have to withstand severe and diverse environmental conditions with respect to temperature, pressure, shock, vibration, acoustic noise, etc. These complex technological demands have led to development of a variety of high quality materials and processing technologies by Indian Space Research Organization to sustain indigenous satellite launch programmes. In their paper, M. C. Mittal, Suseelan Nair, T. G. K. Murthy and S. Satish have described details pertaining to indigenous development of a large number of diverse structural metallic materials, composite materials and special functional materials. The various technologies established include (i) fabrication of rocket motor cases from maraging steels, (ii) electro slag refining of low alloy steels, (iii) investment casting of highly intricate cryogenic engine components of austenitic–ferritic-type cast stainless steel, and (iv) investment casting of superalloys for cryogenic engines. The authors provide details on advanced materials and processes, which are under development for the next generation of Indian space launch vehicles and spacecrafts.

Crystal engineering is recognized today as an important form of supramolecular synthesis and involves understanding of the properties of various intermolecular interactions of different nature, strength and directionalities. The most commercially significant aspect of crystal engineering lies in the study of polymorphic substances used in pharmaceutical industry. G. R. Desiraju discusses the methodologies and strategies involved in crystal engineering.

Aerogels are highly transparent monolithics with porosities as high as up to 99.8%. Aerogels find applications as gas and liquid filters, containers for liquid rocket propellants, absorbers of harmful gaseous effluents, and for confinement of toxic nuclear waste. The steps and procedures employed in preparation of silica aerogels and their properties are discussed by A. Venkateswara Rao.

Shape anisotropy of the constituent molecules is a fundamental requirement for any substance to exhibit liquid crystalline phases or mesophases. The paper by R. Amaranatha Reddy and B. K. Sadashiva contains experimental results pertaining to the relationship between molecular structure and occurrences of banana-shaped compounds, i.e. esters derived from resorcinol and containing five rings.

In the article 'Nuclear reactor fuels and fuel cycles', C. Ganguly mentions briefly about the various reactor systems operating in the world and reviews the intricacies involved in the fabrication of different types of nuclear fuels for research reactors and power reactors. Current scenario with respect to use of metallic fuels, natural uranium, low enriched uranium, uranium–plutonium fuel, mixed uranium–plutonium oxide fuels, mixed uranium–plutonium carbide fuels and U–Pu–Zr metallic fuel is discussed, with special reference to their deployment in pressurized heavy water reactor, light water reactor and liquid metal-cooled fast breeder reactors. The fuel cycle options adopted by different countries, such as open 'once-through' cycle using LEU fuels, closed U^{238}–Pu^{239} cycle, closed and combined U^{238}–Pu^{239} and Th^{232}–U^{233} fuel cycles, proliferation-resistant fuels and fuel cycles are highlighted.

Surfactants are amphiphilic molecules in which there exist a polar and a lipophilic segment. Thermodynamically driven aggregates of surfactant molecules, including those of natural origin (known as lipids) constitute some of the widespread organizations in biological systems. Molecular recognition and self-assembly play a crucial role in living systems such as RNA, DNA and biomembranes. Current trends in the synthesis of various surfactants mentioned above are described by Jayanta Haldar and Santanu Bhattacharya on 'The molecular design of surfactant-based materials'.

The paper by S. Banerjee *et al.* on 'Development of zirconium alloys for nuclear reactors' addresses the challenges faced by materials scientists in tailoring the properties of in-core structural materials of water-cooled reactors and ways to mitigate the in-service damage. The presentation covers fundamental aspects and current understanding of the physical metallurgy of zirconium and its alloys, their deformation behaviour and in-service degradation mechanisms due to corrosion and radiation damage. The article brings out effective utilization of physical/metallurgical principles in the development of zirconium alloys for applications in the aggressive environment of nuclear reactors.

The widespread use of titanium and its alloys in the fabrication of various components in aerospace, defence, atomic energy, spent nuclear fuel reprocessing, conventional power generation, chemical industry, sports goods, ship building and biomedical applications is indicative of their attractive properties under different service conditions. D. Banerjee in his paper on 'Titanium and its alloys and intermetallics' has brought out in chronological order, indigenous developments that have taken place during the last five decades. Titanium-based alloys have, over the years, played a pivotal role in enhancing the performance of gas turbine engines. The difficulties encountered in processing of Ti and its alloys by various public and private sector units in India have also been briefly touched by Banerjee.

The article by O. N. Mohanty on 'New trends in auto body steel' deals with development of various grades of steel and its metallurgy. The evolution of aluminum-killed (extra deep drawing) steels, interstitial-free steels, high-strength-low carbon steels, dual phase steels, and steels with transformation-induced plasticity has been explained with clarity and a perspective. In recent years, Tata Steel has developed various extra deep drawing and interstitial free formable steel grades and explored their physical and mechanical metallurgy aspects. This paper contains details of these developments.

The article by K. Chattopadhyay and Bhattacharya explores status of current efforts concerning the synthesis and understanding of embedded nanoparticles. The paper addresses synthesis of embedded nanoparticles by rapid solidification (including divitrification of metallic glass) and sol-gel routes. The authors have examined the development of nanodispersed microstructure during rapid solidification in monotectic systems. The first ever investigations conducted by authors on effect of phase transition on Giant Magneto Resistance on dispersing FeCo alloy particles in a copper matrix, and the effect of dispersion size on the superconducting transition behaviour of nanodispersion of lead in a glassy Al–Cu–V matrix synthesized by melt spinning are presented.

In the article on 'Refractory metals and alloys', A. K. Suri critically reviews the recent developments of refractory metal extraction, design of alloys and their joining behaviour. The generalized flow sheet, developed at Bhabha Atomic Research Centre, Mumbai for processing of the lean ores of refractory metals is presented.

Metal matrix composites (MMCs) are of great interest because of their advantageous properties, such as high specific strength, high specific stiffness, reduced density, improved high temperature properties, low coefficient of thermal expansion, improved damping, abrasion and wear resistance compared to unreinforced metal matrices. The paper by M. K. Surappa deals with the current state-of-the-art of MMCs with regard to manufacturing processes (solid state, liquid state, reactive processing), microstructural properties and applications. The issues and challenges ahead in intensifying the engineering usage of MMCs are also addressed.

In the article on 'Engineering ceramic composites', Vikram Jayaram has reviewed the powder production routes of advanced ceramics such as Al_2O_3 and Si_3N_4, and various sintering and infiltration methods associated with the fabrication of ceramic matrix composites.

The demand for separated rare earth salts and metals is constantly increasing due to their new-found applications in permanent magnets, high-performance rechargeable batteries, phosphors, auto catalysts, computers, capacitors, etc. In the article by T. K. Mukherjee, development of rare earths technology in India has been presented.

The article by Niranjan Das on 'Development of nickel-based superalloys for gas turbine aerofoils', traces the history of nickel-based superalloys, from their humble beginnings nearly half a century ago to the high technology single crystal components of today. The author has covered the developments that have taken place in the first generation superalloys through improvements in processing (conventionally cast, directionally solidified and single crystal superalloys). The second generation superalloys comprising development of compositions containing rhenium and optimization of composition for creep and oxidation resistance are described.

Madangopal Krishnan discusses developments related to Ni–Ti shape memory alloy fasteners, free recovery components, proportional control applications, actuator or work production applications, psuedoelastic or superplastic applications, smart structures and micromechanical devices. The mechanical aspects of shape recovery, mathematical modelling of shape memory behaviour, constrained recovery, steps in the design of the shape memory alloy fasteners, design of a Ni–Ti–Fe sleeve for fastening polymer pipe connections have also been discussed.

G. K. Dey presents a critical assessment of current engineering applications of amorphous alloys and discusses their physical, mechanical and corrosion behaviours.

In the article on 'Compound semiconducting materials for photovoltaic applications', S. Choudhari and A. K. Pal present a concise review on materials properties required for fabrication of several absorber and window layers of solar cells. The steps involved in the preparation and characterization of several important semiconducting materials in polycrystalline thin film form are also presented. The materials covered include CuInSe, $CuIn_x$, $Ga_{1-x}Se_2$, $CuInS_2$, CuIn $(S_xSe_{1-x})_2$, Cu(In, Ga) $(S, Se)_2$, (CdTe, ZnTe, InP, Zn), CdS, ZnSe and indium–tin oxide. Current developments in organic materials for solar cell applications have been briefly mentioned.

Aluminum alloy matrix composites (AMCs) are being increasingly used in high-technology structural and functional applications. The article by S. Das *et al.* on 'Reinforced aluminum alloy matrix composites' describes the solidification synthesis of AMCs, their mechanical and tribological properties. The performance behaviour of several automobile parts made out of AMCs is also reported.

T. S. Radhakrishnan surveys available information on superconductivity of (i) chevral phase compounds with emphasis on magnetism and structural integrity, (ii) doped fullerenes, (iii) quarternary borocarbides, (iv) Nb–Ti, (v) Nb_3Sn, and (vi) ternary molybdenum chalcogenides ($PbMo_6S_8$). The application areas of superconducting quantum interference devices have been mentioned. The Indian efforts in the development of HTSC and LTSC superconductors and future directions in superconductivity research are highlighted.

In the article on photonic materials, V. K. Wadhwan presents the currently available grades and Indian efforts in developing and processing these grades. Materials used for photo detectors and imaging, and optical communication systems have also been discussed.

E. V. Sampath Kumaran gives details pertaining to anomalous 4f electron behaviour and points out application potential due to unusual magnetic characteristics. Cerium materials exhibiting the Kondo effect and the consequences of its competition with magnetism are demonstrated. It has been brought out that magnetic characteristics of Ce-based materials can be drastically altered by alloying, external pressure, and temperature. The mechanisms responsible for unusually large enhancement of T_N in $PrCu_2Si_2$ and $PrCu_2Ge_2$, mixed valent Eu-compounds and Yb-based mixed valent and heavy-fermion compounds have been discussed.

In the article on smart sensors and actuators, S. B. Krupanidhi introduces some of the materials, which form the functional body for most of the present sensor and actuator technology categories. These materials have been dealt according to the purpose they serve. The paper describes physical (thermal, electrical, mechanical, piezoelectric, piezo-resistive, magnetic), chemical and bio-medical sensors. Smart and intelligent sensors are introduced to the reader. The methods of transferring energy into motion, microactuators, material considerations in smart systems, smart ceramics, relaxo ferroelectrics, shape memory alloys, functional composites, electrorheological fluids and piezo-electrics have also been covered.

In the article by K. S. Narayan on 'Polymers as active materials for electronic application', the phenomena involving charge transport, recombination (electroluminescence) and charge separation (photoconductivity) have been discussed. The challenges facing further development of polymers for electronic applications have been outlined.

Artificially structured multilayered materials are formed by depositing stacks of nanometre-sized layers of two or more materials. It is possible to tune electrical, magnetic, optical and mechanical properties of these materials by controlling shape of 1D periodicity and the structure of surfaces and interfaces. In superconductors, the directional nature of chemical bonds results in the formation of high quality superlattices. The crystal growth by molecular beam epitaxy enables the layer-by-layer deposition of a variety of semiconductors, metals and insulators, and practically any combination thereof. Strained layer epitaxy has enabled to tailor the band-gap almost at will. Atomically engineered metallic, multilayered materials are promising candidates for reading heads in the next generation of high-density data storage systems and future magneto-optic recording media. In the article by M. K. Sanyal *et al.*, on multilayered structures, the present status and the possible future of various multilayered structures have been discussed.

The paper by S. Ahmad deals with material-related problems in the information technology area. Si, along with SiGe, is poised for handling radiofrequency signals. It is mentioned that fragile GaAs and InP families are slowly going to be replaced by more robust and high power materials like SiC and GaN in near future.

A functionally graded material (FGM) is characterized by a gradual change of material properties with position, the change having been designed. The property gradient in the material is caused by a position-dependent chemical composition, microstructure, or atomic order. In the article on 'Functionally graded materials – A brief review', P. C. Deb has attempted to cover important aspects of FGM processing as applied to various materials, and touches upon basic principles relevant to such processing with examples. The methods discussed include powder metallurgy, infiltration (liquid–solid processing), plasma spray forming, vapour deposition, electrophoretic and electrochemical methods, polymerization and self-sustained high temperature synthesis.

The scientific interest in amorphous forms of carbon has found renewed significance in recent times, owing to its rich underlying physics and rich application avenues. The widely known forms of amorphous carbon are carbon black, carbon fibres, porous carbon, glassy carbon, diamond-like carbon and pyrocarbon. B. Gopalakrishnan *et al.* describe progress towards the synthesis and characterization of properties of amorphous conducting carbon and carbon nitride. A brief mention has been made on various methods employed for preparation of amorphous carbon. The general features of conducting amorphous carbon and its doping are presented.

It is an enormous task to cover a wide range of materials, their processing and properties in a single volume; so inevitably, selection of articles had to be made. The overall impression of this book is that it is not an encyclopaedia (concise and comprehensive) as one might be led to expect: it is a collection of articles which range from general reviews to specific discussions of narrow areas. Most of the articles, written by specialists, are extremely valuable and define current scenario and direction of research as promised in the title of the book. Some of the articles suffer from lack of in-depth literature review in the subject matter of interest and critical discussions. The drawback of these articles is that, understandably, they emphasize the areas with which authors are familiar but neglect other aspects in the selected topics, which should have been given equal weightage. This book achieves the objective of being a resource book to students at all levels. Researchers would find it to be of value to get a perspective and get motivated by the excitements and challenges in materials science. We wish that all the authors had been encyclopaedic in approach.

BALDEV RAJ*
K. BHANU SANKARA RAO

Indira Gandhi Centre for Atomic Research, Kalpakkam 603 102, India
**For correspondence.*
e-mail: dmg@igcar.ernet.in