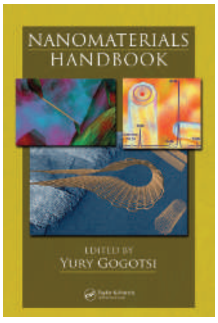
Nanotubes and much more



NANOMATERIALS HANDBOOK EDITED BY YURY GOGOTSI

CRC Press: 2006. 780 pp. $149.95

A vast army of nanoexplorers is on the march and making rapid progress in so many directions that no one is able to map them all. However, the *Nanomaterials Handbook*, edited by Yury Gogotsi of Drexel University in Philadelphia, provides a valuable snapshot of present advances and plans for the future.

The accelerating pace and magnitude of these advances indicates the need for this snapshot, as well as for frequent updates, and Gogotsi has been outstandingly successful in persuading leading researchers to write seminal chapters that will enlighten both experts and beginners who have strong backgrounds in the physical sciences.

The understandable time lag between completion of chapters and publication is problematic for those chapters that deal with especially dynamic areas of nanotechnology. For example, about 2,900 journal articles with "carbon nanotube" in the title appeared last year, which is almost 30% of the total for the previous decade, yet there are few references to publications from 2005 in this handbook. One wonders if web resources — including a possible Wikipedia-style site exclusively devoted to nanotechnology — will eventually trump handbooks in rapidly evolving areas by providing reviews that are continuously updated.

The strengths of this handbook far outweigh these problems. With 27 chapters, 780 pages, over 3,700 references, and 62 authors, it provides valuable information and insights on a host of nanomaterials including many different forms of carbon (fullerenes, nanotubes, diamond, carbides and so on), inorganic nanotubes and nanofibres, ceramics, superconductors, thermoelectrics, polymers, nanocomposites and nanostructured coatings. Synthesis, structure, processing and the remarkable properties achievable on the nanoscale are described for many materials. The range of applications discussed is equally wide — electrical energy storage and harvesting, hydrogen storage, solar cells, field-emission materials, drug delivery, biosensors and much more. On the downside, the use of black and white throughout the handbook reduces the value of figures originally published in colour, and some very detailed micrographs do not reproduce well.

The *Nanomaterials Handbook* is also available in an electronic form that will certainly be a valuable library resource for those interested in downloading just a few chapters, or for talented high-school students working on graduation or science-fair projects. To see if the handbook might be suitable for high-school students, we asked the very bright youngsters who take part in the NanoExplorers programme at the University of Texas at Dallas to evaluate it. However, many found the language and concepts too specialized and difficult, unless studying with a mentor, and turned to Wikipedia for help. Of course full-time researchers, not high-school students, are the intended readership for the handbook.

So what is exciting in the world of nanomaterials and what are the problems? New and useful properties, resulting from confinement effects in one, two or three dimensions, are now well established in many systems. Breaking this confinement in nanoparticles, for example to quench fluorescence as a result of interparticle coupling, is finding real applications in the detection of minute quantities of specific biological agents. Elsewhere, the ability to control independently the movement of phonons and electrons on the nanoscale is leading to improvements in refrigerators and devices that harvest thermal energy, as described in the chapter on low-dimensional thermoelectricity.

Although nanotechnology was unknowingly applied to produce beautifully coloured glass in the late Bronze Age, and carbon nanoparticles have been widely used to strengthen tyres since 1915, the enormous economic potential of nanotechnology has not yet been realized. Part of the problem in areas such as nanoelectronics and displays based on carbon nanotubes is that the new nanotechnologies have to displace entrenched technologies that come complete with billion-dollar manufacturing facilities. Another problem for some key materials, like carbon nanotubes, is the absence of methods to fabricate trillions of nanotubes with identical properties. Although individual carbon nanotubes have demonstrated spectacular properties, bulk samples (sheets and yarns, for example) have much lower performance at present.

The readers of the *Nanomaterials Handbook* might help solve these problems and enable nanotechnology to achieve its full commercial potential. The chapter on nanocrystalline diamond, for instance, is particularly fascinating because it demonstrates that many lesser-known nanomaterials offer similarly interesting commercial possibilities as more celebrated systems, such as nanotubes.

Readers who want a global perspective will benefit from the sheer diversity of the material in the handbook, as will those who prefer to jump from topic to topic.

Indeed, the broad perspective provided by the handbook helps prepare the dedicated reader to exploit the interdisciplinary nature of nanotechnology as many of the most significant and exciting advances are made at the interface between different disciplines, and because insights and methods developed for one family of materials can often be applied to others. From talented undergraduates to world experts, many readers will benefit from this book.

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