BOOK REVIEW

Nanotechnology: Basic Science and Emerging Technologies

By Michael Wilson, Kamali Kannagara, Geoff Smith, Michelle Simmons and Burkhard Raguse,
Chapman and Hall / CRC Press, 2002, 271 pages plus 15 pages front material, ISBN 1-58488-339-1,
Price $59.95.

These five Australian authors claim to have provided the first textbook on nanotechnology, a concept which they perceive is about to become a major shaper of new technologies as well as a social talking point. There is as yet little understanding even amongst the educated public as to what nanotechnology is about. It started as a 'buzzword' some ten years ago (1, 2) and is now developing into a topic which has the potential to equal genetic engineering in its importance.

This nanotechnology text has the stated aim of bridging the gap between highly detailed specialist publications and the generalities of the speculative science books and to a large extent achieves this objective. The book begins by providing a basic background in the subject and then moves on to cover such topics as molecular nanotechnology, nanomaterials and nanopowders, nanoelectronics, optics, photonics and solar energy, and nanobiomimetrics. Some additional features which make the book very easy to understand are the definitions of concepts such as atomic structure and various forms of energy, and the descriptions of techniques such as Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Probe Microscopy (SPM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), Nanomanipulators, Nanotweezers, Self Assembly, and Dip-Pen Nanolithography (DPN). The tools of nano and micro fabrication, such as optical and electron beam lithography and molecular beam epitaxy are also described.

The potential importance of the use of gold in helping nanotechnology to make progress is somewhat underplayed in this textbook but nevertheless its advantageous employment is described in seven different places. Nanotechnology lies somewhere between macroscopic structure, devices and machines on the one hand and atomic/molecular dimensions on the other but it is closer to the latter (1). Conducting transition metals, such as iron, copper, silver and gold are likely to play key roles arising from their useful electrical properties, but gold will usually be the best in this regard since it has a high conductivity coupled with chemical stability. Gold nanotubules in plastic provide a nanocomposite used for selective ion separations. Gold particles of < 50 nm have a characteristic visible absorption band called the plasmon resonance absorption which makes them pink and their interaction with key components in body fluids could be made a basis for a 'First Response' home pregnancy test. In a chapter entitled 'Molecular Mimics', a need for optimal electrical contacting is highlighted and pre-structured gold can be used to get preferred molecule orientation in flow adsorption.

In explaining the variables operational in self-assembled monolayers, *ie* monolayers that are formed on surfaces by a self-assembly process, the importance of the strong interaction between the thiol group and gold is emphasized. A monolayer of alkane thiols attaches itself to the gold surface *via* the thiol group (2). The hydrocarbon tails line up and point away from the surface. The driving force is the bond formation between the head thiol group and the gold surface atoms: thus once the head group is covered with a monolayer of surface molecules, further alkane thiols will not absorb. The gold substrate can be removed from the solution and rinsed to remove excess alkane thiol, leaving a surface which is covered with a monolayer of molecules. Gold really comes into its own in this application and provides an effective means of controlling the surface properties of materials!

Gold and silver form a basis for new low cost energy efficient windows and solar absorbers based on nanotechnology. These metals propagate electromagnetic waves or photons internally, but after a short, nanometre scale distance, they are destroyed by absorption. If the metal is thin enough (under 200 nm) some light can get through. Thin films can be deposited on glass or plastic in vacuum to give transparent coatings. Using other special non-metal dielectric nanolayers, such as titanium dioxide on either side of the metal, the amount of light passing through can be increased to make the coated metal almost clear and transparent. Since the light is transmitted rather than reflected there is no glare. If nanosized particles rather than thin films are used, they can play a similar role.

As far as applications are concerned, the authors envisage that the laboratory nanoelectromechanical (NEMS) systems being developed could replace some of their micro equivalents (MEMS) (3) and some functions envisaged can only be performed at the NEMS level: gold is likely to be the preferred choice of metal in these devices. Other innovations

could include ageless materials, and invisible mending of atomic dislocations inside damaged materials. New effects can be produced by special nanoparticle coatings (2), and new nano-electronic, -optic and –magnetic devices are foreseen and some of these could be used in new computing systems.

Although the importance of nanotechnology in improving the performance of catalysts is mentioned on at least two occasions, the authors have not included the specific example of catalysis by gold, and this may be due to the very recent emergence of the importance of this topic. It is now an established fact that dispersing gold nanoparticles on oxide supports, rather than using the gold as supported macroparticles or in the massive form, has transformed gold from being a catalytic metal of minor importance to being the catalyst of choice for some commercially important reactions (2).

Altogether, the ten chapters provide a good foundation for thinking about applications for nanotechnology and the book is well illustrated, including explanatory diagrams to assist in the understanding of scientific principles. Nanotechnology is a multidisciplinary science and all scientists who investigate the solid state are likely to find parts of this book helpful: and it is certainly suitable for non-experts as a way of getting into the topic. At the end of each chapter there are summaries of what the reader should have learnt from them and exercises to test this knowledge. Re-publication by Chapman and Hall/CRC Press is therefore welcome after the earlier issue by the University of New South Wales Press. The development of nanotechnology is still at an early stage but exciting progress has already been made. It is useful to have this stimulating and readable book as a basis upon which to build one's knowledge of the field.

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