Image–Based Fractal Description of Microstructures

Published by Kluwer Academic Publishers, by J. M. Li, Li Lü, M. O. Lai and B. Ralph, 2003, pp. 1–273.

The realisation that the geometrical properties of rough objects cannot be treated in the same way as those of smooth objects is now decades old. Measures such as perimeter and surface area are not well–defined for rough objects because they depend on the resolution of the measuring technique. Thus, a child walking around a coastline will measure a larger perimeter than an adult who has a longer foot–span. The child is able to penetrate nooks and crannies in the perimeter which the adult cannot.

Mandelbrot's discovery that the dependence of these properties on resolution can be expressed in terms of a fundamental parameter, the fractal dimension, has changed the way in which scientists perceive objects. The essence of the theory is easy to understand, but in the context of materials science, can be difficult to implement. This book fills a large gap in the readable literature on fractals, and is all the more welcome because its contents are thrilling.

It contains a clear and yet uncompromising exposition of fractals. Considerable effort is devoted to the mathematical and experimental techniques for the characterisation of fractal dimensions of the structures of materials. Even the mechanisms of imaging when using a scanning electron microscope are discussed in the context of extracting relevant information.

I particularly like the discussion of real microstructures, *i.e.* those where the fractal character is limited to certain measurement scales. The ideal fractal, where self–similarity propagates over an infinite range of observation clearly does not apply to most materials issues.

The treatment of the kinetics of the rough graphite nodule is truly elegant; it is shocking that this is the first time I have encountered this theory in spite of all the conferences I attend. The theory goes far beyond the crude applications of diffusion–controlled growth models based on smooth objects.

I have always imagined fractal theory to be important in the context of fracture surfaces. This book almost destroys that illusion, in that it demonstrates that this general conclusion is not justified. This is because fracture surfaces simply do not show self–similarity over typical scales of observation. They can become smooth at a high enough magnification, making the fractal dimension change with magnification. The claim that there is a universal, material–independent fractal dimension associated with fractographs is not correct.

Some of the statements are obvious in hindsight, but well worth reminding the reader. For example, there is no reason to expect a correlation between fractals and mechanical properties when the latter are controlled by non–geometrical factors. The authors have attempted throughout the book to give a physical meaning to fractal parameters. Thus, my use of the term "rough" in this review may not meet their approval. The rigorous meaning is apparently that a fractal dimension characterises the extent to which an object fills the space in which it is embedded. Clear and concise!

The book achieves precisely its aims, to be a source for researchers. It is worth repeating that the book is very readable in spite of the technical nature of the subject. I believe that this is because the authors have an impressive understanding of the subject. I have no hesitation in recommending it to scholars of all kinds. I once attended a lecture by Mandlebrot – I have to say that I learnt a lot more from this book!