Book review

D. R. F. West and N. Saunders: **'Ternary phase diagrams in materials science'**, 3rd edn, 2002, London, Maney Publishing, xii + 224 pp., casebound, **£50**, ISBN 1 902653 52 1

Materials science is now a broad subject which spans the pure sciences and contains many aspects of engineering. There are demonstrated benefits which accrue from this approach, but it is also the case that there is a lack of depth in the teaching of materials. Take for example, phase diagrams. The theory for unary and binary phase diagrams is well taught; every materials undergraduate is expected to understand the nature of equilibrium and the thermodynamic basis of the diagrams, the concepts of tie lines and the lever rule, and three-phase equilibria in the context of the eutectic reaction. Is it then necessary to learn about *ternary* phase diagrams?

The answer becomes apparent on reading the very first chapter of this book. The are significant differences between the binary and ternary systems, both in terms of the degrees of freedom and in their representation on diagrams. For example, the lever rule applied to tie lines in a binary becomes the centre of gravity rule applied to tie-triangles. Seems obvious enough on reading chapter 1, but I have seen research papers and industrial reports which fail to appreciate this. The consequence of using the binary procedure to calculate the phase fraction in a ternary is bizarre: the fraction calculated using one component is different from that using another component!

Another distinguishing feature in ternaries is that tie-lines do not necessary lie in the plane of a vertical section of the ternary phase diagram. Such a section cannot therefore be used to obtain the fractions or compositions of the phases represented. I once was asked why the pearlite reaction in Hadfield manganese steel never goes to completion during isothermal transformation. The answer is that the additional degree of freedom available in ternary systems means that the eutectoid reaction can occur over a range of temperatures. Within this range, the austenite, ferrite and cementite can co-exist in equilibrium, whereas in a binary Fe–C system the three-phase equilibrium exists only at a unique temperature.

My view is that chapters 1, 3 and 4 should form essential reading for undergraduates in materials science. They introduce ternary phase diagrams in a logical and readable style, with excellent diagrams to help the reader visualise three-dimensional effects. Chapter 2 is a new addition to the book, with the aim of introducing the thermodynamic models which form the basis of phase diagram calculations. The chapter also introduces binary phase diagrams of polymers and makes some interesting comparisons against metals and ceramics. Bulk polymers contain molecules with a variety of weights; it should therefore be necessary to define the molecular weight distribution when representing phases on an equilibrium phase diagram, which in effect means that there will be an infinite variety of phases possible! Weak cross-linking can lead to a separation of phases as the temperature is *raised*. But apart from these oddities, polymer phase diagrams are not essentially different from those of any other materials. I have mixed feelings about chapter 2, which does not fit well in a book on ternary phase diagrams; the thermodynamic treatment is essentially binary. On the other hand, a more sophisticated treatment of solution models would lengthen the book and I much prefer the size as it is.

Beyond chapter 4, the book goes into considerable depth into a variety of scenarios: ternary eutectics constituted from binary eutectics, combinations of binary peritectics with eutectics, etc. This last example highlights another distinction of ternaries, in that it is possible to get a smooth transition from a ternary peritectic to a ternary eutectic by changing the chemical composition. There is a brief introduction to non-equilibrium solidification in chapter 8; it would be good in a future edition to include a similarly brief section on paraequilibrium.

As a teacher I particularly appreciate the continued provision of carefully constructed problems and corresponding outline answers. But these problems, together with the expanded set of case studies should be useful to all readers given that they reinforce the principles explained in the main body of the text.

In summary, the book is a delight to read and is the perfect size to cover the essence of ternary phase diagrams. It should be useful to undergraduates and researchers alike. I would recommend that in a future edition the phrase 'in materials science' should be removed from the title because the contents are of use in many disciplines including materials science, earth science, biology, chemistry, physics, engineering, etc. I have even come across phase diagrams for ice cream!

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