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book reviews

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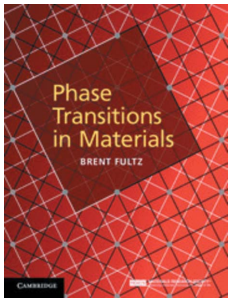

Phase Transitions in Materials. By Brent Fultz. Cambridge University Press, 2014. Pp. 583. Price GBP 60, US$ 90. ISBN 9781107067240.

I shall start by saying that this book is not for the faint-hearted, nor is it for people who view phase transitions in crystal structural terms. What this book is, is a highly theoretical treatment of the kind of phase transformations that materials scientists get excited about, and that normally means metals and alloys. I guess the title misled me, as it would have been preferable if it had been called '*The Theory of Phase Transformations in Materials Science*'. So, do not expect to find here anything much on organic and inorganic crystals, and how they transform, nor anything to do with crystal structures and their properties. I was therefore a little disappointed in the book's content. Nonetheless, if you are interested in materials science, defects, thermodynamics, diffusion, alloys *etc.* then this book could be for you. It is a rather large book, divided into four sections with a total of 24 chapters, each one ending in a set of problems, and generally well written. Let me take you briefly through the individual chapters so that you can get an idea of what this book is about.

Part I, entitled *Thermodynamics and Kinetics of Phase Transformations*, contains five chapters, starting with a simple thermodynamic description mainly devoted to pure elements and aspects of kinetics. This is followed by temperature–composition phase diagrams, free energies, the usual Hume–Rothery discussion familiar to metallurgists, the common tangent used in phase diagrams, solid solution and the Bragg–Williams theory of long-range order. Then we have a discussion of diffusion, nucleation, surface energy, free energy curves, quenching, alloy solidification, glass formation and reactions at surfaces.

Part II is called *The Atomic Origins of Thermodynamics and Kinetics*, and has four chapters. This begins with energy, the diatomic molecule and molecular orbital theory, energy bands, translational symmetry, Fermi energy, band structure of alloys, all the usual stuff you find in most solid-state physics texts. We then go on to entropy, short-range order and the pair approximation, clusters and the Ising lattice. Pressure is then described with gases and solids for comparison, the usual Clausius–Clapeyron theory well known to undergraduates, and the two level system under pressure. Finally atomic movements with vacancy mechanisms, random walks and correlations in alloys are described.

Part III is on *Types of Phase Transformations*. This begins with melting and chemical trends in the melting of elements, including an interesting periodic table diagram for melting temperatures. It is interesting also to see Lindemann's rule being mentioned. This a nice, but unprovable rule that seems to work: A crystal melts when its atomic vibrations reach 10% of the interatomic spacing. Curiously for a book on the solid state, the term Wigner–Seitz appears in connection with this rule, and without explanation as to what it is. Guinier–Preston zones, surface reconstruction, grain boundaries and defects and the Avrami theory follow. Then there are chapters dealing with spinodal decomposition and concentration fluctuations, phase field theory, concentration waves, the usual Martensitic transformation beloved of all materials scientists, diffusionless transformations, and the thermodynamics of nanomaterials. One chapter contains the briefest of discussions of Brillouin zones, only in one dimension, in my view a lost opportunity to describe the Wigner–Seitz construction for three-dimensional crystals! There is a chapter on magnetic and electronic phase transitions that includes spin waves, correlated electrons and a really derisory few lines on ferroelectric transitions. Note no discussion of ferroelastics nor of ferroics in general. This part of the book ends with phase transitions in quantum materials, which means to the author Bose–Einstein condensation, superfluidity and superconductivity.

The last part is on *Advanced Topics*, consisting of six chapters on a number of diverse topics including low-temperature analysis of phase boundaries, cooperative behaviour near critical temperatures, inelastic scattering and vibrational thermodynamics.

In conclusion, do not expect to find much crystallography here, and indeed the little that there is is problematic. The author, clearly a typical theoretician, seems to think that all crystals are cubic and there are a number of statements that can make a grown crystallographer cry. For example, on page 335 we read 'Perhaps the most important is that the reciprocal lattice of a body-centred cubic (b.c.c.) crystal is a face-centred cubic (f.c.c.) crystal, and *vice versa*'. So a lattice is a crystal? And does it matter if it is cubic? And then in the footnote is this tortuous beast: 'The missing diffraction peaks, such as (100) in both f.c.c. and b.c.c., or (110) in f.c.c., are consequences of using a simple cubic lattice for reference, instead of the nonorthogonal primitive lattice vectors of the real space f.c.c. and b.c.c. structures. The Cartesian axis reference frame is more convenient, however, so we are accustomed to using 'structure factor rules', which are derived for a cubic lattice with basis vectors'. Eh, what?

So, would I recommend this book? Probably not for crystallographers interested in structural phase transitions, although for those interested in metals and alloys and general materials science this book should be useful. It is very thor-

ough and informative, although it lacks many real world examples, being mainly a theory text book.

A. M. Glazer

Physics Department, Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, England