Book reviews

Very rich spring 1994, new books have accumulated on my desk and I wish to share with the readers of Microscopy, Microanalysis and Microstructures the pleasure of skimming through them. Without any preferential order, let's discover what's new !

Electron Microdiffraction
by J.C.H. Spence and J.M. Zuo
(Plenum Press, New York and London,1992)

This is not the most recent book out of the printer but I have discovered it only recently as I was trying to understand the mechanisms of image formation in a projection microscope using electrons of very low energy emitted from a point source. This is to say that the book may become most useful to readers who are not particularly involved in electron microdiffraction. Of course the basic content of the text deals with the geometry of CBED patterns, the theory required to understand them and the most useful applications within the two-, three- and many-beam frames. The reader can also find a short chapter on the large angle methods known as LACBED, and on the determination of point and space groups which are well inserted in the general context but are not, of course, as complete as the well known reference publications by the Bristol and Sendai groups on these subjects. The final chapters are more original and deal with recent aspects under rapid development thanks to the availability of field emission sources and energy filtering devices. In particular they discuss the potential impact of coherent nanoprobes and instrumental progress in detectors and filtering devices. Over the 350 pages, about one hundred are made of appendix dedicated to crystallographic data, indexing of diffraction patterns, computer programs, which constitute a quite useful and practical complement to the text.
The basic spirit of the book is to demonstrate how the field of convergent beam electron diffraction which had for many years remained essentially qualitatively used for symmetry analysis and phase identification has begun to move into a more quantitative field. This has been largely initiated by the research of the two authors themselves on accurate structure factor phase measurements which are extensively described in chapter 5 in particular. As a consequence of two main developments which have contributed to this improvement (access to elastically filtered data and introduction of automatic dynamical refinement methods) quantitative electron diffraction has become more accurate (for certain problems) than X-ray or neutron work. This is a turning-point which should not be missed. It is clear that crystallographers "at large" should read this very complete and clear discussion of dynamical theory and developments to take full benefit of these new possibilities.
In conclusion this is a book of real value not particularly dedicated to novices in the field but to all those who wish to update their basic knowledge in convergent beam microdiffraction. And it provides a few nice and simple ideas on closely related fields such as image formation in STEM and in projection microscopy.

Electron beam analysis of materials
by M.H. Loretto
(Chapman and Hall, London, 2nd edition 1994)

At the opposite of the previous title, the present book is written at an elementary level and must be considered as a support for teaching purposes at undergraduate or graduate levels in a Materials Science Department, rather than as a support to scientists involved in research work. Its content is quite wide, from an elementary description of the electron optics and beam-matter interactions to a review of all pertinent modes of operation. It begins with a general lay-out of different types of electron beam instruments and continues with three major chapters dealing respectively with the interpretation of diffraction patterns, of micrographs in various imaging modes and of analytical data delivered by X-ray, EELS and Auger spectrometers. As the total length of the book is of the order of 230 pages including a good number of nice illustrations and clear tables (plus about thirty pages of appendix) it is obvious that such a broad content can only be described in elementary and sometimes superficial terms, see for instance the interpretation of high resolution electron micrographs or the discussion of detection limits in analytical electron microscopy. In both cases the absence of realistic figures accessible with the present state of the art techniques is unfortunate.
This is an updated version so that many recent developments are mentioned : there is for instance a clear reference to the large angle annular dark field imaging of resolved atomic columns in the STEM, a well illustrated introduction to the analysis of imperfections in crystals using the LACBED technique. But on the other hand one can regret that the electron energy loss spectroscopy technique is only illustrated by two poorly drawn schematic drawings while it would have been more interesting to show some real spectra to accompany the type of quantitation available.
In his preface, the author indicates that a comprehensive list of references has been added at the end of each chapter. I must confess that the efforts put to update those existing in the first version of the book must have remained very limited. I have looked at those at the end of the chapter on the interpretation of analytical data. All of them date from before the first edition (1984) except a few refering essentially to some work of the author's group.
Briefly speaking this is a good general introduction to the field of electron microscopy of materials for beginners, rather attractive in its format, with a reduced number of equations and a good level of illustrations. On the other hand its interest remains limited for those actively involved in research work using these techniques.

Electron holography
by A. Tonomura
(Springer-Verlag, Berlin Heidelberg 1993)

Here is a short book, 120 pages long, but at the real frontline of the present research. The author has initiated and pursued over more than 20 years an original work at Hitachi on the realization and use of field emission sources. There is consequently no mystery that he has become the greatest expert in using "coherent" sources of electrons. Coherence of an electron beam, both longitudinal (or temporal) and transversal (or spatial), makes possible to observe a great number of interference fringes on the observation screen and on the recording device. In particular it opens the way to recording holograms which are obtained as the interference pattern between a reference and a scattered wave.
The present state of electron holography deserves a whole book and the text by A. Tonomura superbly fulfils this duty. If holography has been actually invented by Dennis Gabor in 1949 as a way of breaking through the resolution limits of electron microscopes, electron holography has

only been made possible with the advent of coherent electron beams in the seventies in particular thanks to the efforts of Tonomura and colleagues. It has then opened many new areas such as the observation of magnetic domain structures, of fluxons in superconductors, and given access to fundamental experiments in physics such as the confirmation of tha Aharonov-Bohm effect.
The content of the book is made of a few introductory short chapters on the principles of holography, on electron optics with appropriate comments on coherence properties and a very nice image depicting the single-electron build up of an electron interference pattern, and on the history of the technique. The practical aspects of recording holograms and reconstructing the object are then described in simple terms and illustrated with pedagogic documents. A long and fully argued chapter is then devoted to the famous Aharonov-Bohm effect which stipulates that electromagnetic potentials in quantum theory have physical significance. To prove it Tonomura et al. have realized in 1986 a decisive experimental test using toroidal magnets covered with a superconducting field in order to avoid any overlap between the magnetic field and the electron beam. This was a real instrumental achievement!
Applications of electron-holographic interferometry to a large variety of specimens and problems constitute the heart of the last two chapters. It can be applied to thickness measurements, to surface topography investigations (see for instance the interferogram of a GaAs surface with a single screw dislocation), to the visualization of electric and magnetic fields and finally to the correction of aberrations. But the most spectacular result in my own opinion is the direct visualization of fluxons in superconductors, not only in the profile mode when they protrude from the sample but also, and this is quite new, in the transmission mode. The images at the end of chapter seven constitute the long-time searched real demonstration of the existence of a fluxon lattice in a superconducting film. And I know, having recently visited A. Tonomura 's laboratory, that you can follow the dynamics of this lattice in real time under variation of the temperature or of the applied magnetic field. This opens quite new avenues for investigating the mechanisms of the fluxons displacements and improving our understanding of the parameters controlling the magnitude of the critical currents.
If you are interested by first quality experiments in physics made with an electron microscope (maybe you will not be capable of acquiring this type of machine for your own experiments!), you must at least acquire rapidly this fascinating short and easy-to-read book.

More titles to be reviewed in the next issue!

Christian Colliex
Laboratoire de Physique des Solides
Université Paris- Sud
91405 Orsay, France