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book reviews

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Diffraction des rayons X sur échantillons polycristallins. By René Guinebretiere. Lavoisier: Hermes Science Publications, 2002. Pp. 286. Price EUR 70. ISBN 2-7462-0557-2.

X-ray scattering by polycrystalline aggregates is a very broad domain which encompasses research fields as diverse as structure determination, quantitative phase analysis, crystalline ratio analysis, quantitative texture analysis, residual stress, stacking faults, crystallite size determination, and microstrain analysis. Each of these fields has become progressively specialized, focussing on one or other aspect, but the scattered X-ray patterns contain signatures of all these effects.

Thus it is a difficult task to provide a compilation of these research domains in a single book without becoming too diffuse or going into too much confusing detail. However, the author succeeds in this textbook, which is dedicated to BS students, beginners in crystallography, and to more advanced students (MS, PhD) and researchers. The materials scientist whose task is to monitor and analyse X-ray diffraction and interference in polycrystalline materials will find here a useful menu of starters, complete first and second dishes, and further guidance, if necessary, using the bibliography. The author concentrates on the basics of each discipline without repeating or elaborating sophisticated methodologies already developed in specialized literature.

As appetizers, chapter 1 starts with historical aspects of the discovery of X-rays by W. C. Röntgen, along with observations of their first uses in radiography, continuing to the W. Friedrich, P. Knipping and M. von Laue observations of X-ray diffraction by single crystals. The chapter summarizes the important work by J. J. Thomson, G. Sagnac, J. S. Townsend and other pioneers and ends with the experiments on polycrystals by W. H. and W. L. Bragg. Nearly all the early results from the beginning of the past century are well documented and would serve most teachers as introductory works.

Chapter 2 presents X-ray scattering theory. Thomson and Compton single-electron scattering models are first described, with the usual extension to single- and multiple-electron atoms. Diffraction of X-rays by ideal, then real single crystals is developed from the kinematical point of view, and applied to polycrystalline powders. The theoretical side expands to powders derived from imperfect crystals, with specific emphases on the effects of point, planar and volume defects, such as disordered or clustered vacancies, atomic relaxations from interstitials, stacking faults, crystal sizes and microstrains. In this treatment, diffuse scattering is introduced in the kinematic formalism for the simplest cases.

An important instrumentation chapter follows. X-ray production by classical and synchrotron sources is described, together with beam filtration, monochromatization and detection. Experimental arrangements such as multilayered, parabolic, elliptic or hybrid monochromators are illustrated, as are the increasingly employed linear or curved position-sensitive detectors, charge-coupled device (CCD) and image-plate detectors. The Debye–Scherrer, Bragg–Brentano, Seemann–Bohlin conventional focusing settings are described, followed by more recent setups using parallel beams in various monochromated and collimated systems. The author naturally comes to the description of diffractometers built for the characterization of thin layers, a field of growing interest. In this latter part, the beam penetration effects on diffracted intensities are illustrated for some experimental arrangements as a basis for easy application to other goniometers. Polycrystalline textured epitaxial layers are addressed in this section, as characterized by four-circle diffractometry.

Chapter 5 deals with data treatment and analysis. Line profiles, instrumental aberrations including axial divergence, slit functions and spectral width are introduced in the description of the instrumental resolution. Pattern simulation is then fully described, along with pattern matching and structurally constrained approaches within the Rietveld-like methodology. The line profile functions are also introduced here.

The final chapter is a descriptive summary of the methods regularly used in the characterization of materials by X-rays. Phase identification is the starting point for quantitative phase analysis. In this, grain statistics and differential absorptions are introduced before the phase quantification procedure using integrated intensity extraction by direct or standard methods. Indexing and cell refinement are then presented before moving on to structural analysis. The Patterson function and Fourier section and projection are introduced for single-crystal analysis. Rietveld analysis is then used in examples of structural determination of polycrystalline samples. Microstructural analysis using the integral width, both isotropic and anisotropic, and Fourier analysis are detailed. The last part of the chapter is dedicated to thin-sample characterization. The examples chosen by the author are nice illustrations of the use of X-rays for various types of analysis, with interesting illustrations of qualitative measurements of the preferred orientation of thin films using different scanning strategies.

It is perhaps regrettable that the author did not devote a few pages to a quantitative description of texture using the now classical methods of the orientation distribution function, to the characterization of residual stresses of simple isotropic samples, and to the description of the combined approaches nowadays increasingly used for non-destructive characterization. Written in French, the book may suffer from a lack of readers from many countries. Fortunately, many clean illustrations and mathematical expressions will make it useful to non-French speakers.

With 284 pages, around 280 references and a nicely built index, this book will be of strong interest for students with the necessary mathematical knowledge, and to teachers and scientists working in the fields of X-ray diffraction and materials science.

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