Preface

Since the discovery of the Mössbauer Effect many excellent books have been published for researchers and for doctoral and master level students. However, there appears to be no textbook available for final year bachelor students, nor for people working in industry who have received only basic courses in classical mechanics, electromagnetism, quantum mechanics, chemistry and materials science. The challenge of this book is to give an introduction to Mössbauer Spectroscopy for this level.

The ultimate goal of this book is to give the reader not only a scientific introduction to the technique, but also to demonstrate in an attractive way the power of Mössbauer spectroscopy in many fields of science, in order to create interest among the readers in joining the community of Mössbauer spectroscopists. This is particularly important at times where in many Mössbauer laboratories succession is at stake. This book is based on tutorial lectures, organized at the occasion of the 2011 International Conference on the Application of Mössbauer Spectroscopy (ICAME2011) in Kobe.

In Chap. 1 is written by Saburo Nasu, the reader will find a general introduction to Mössbauer Spectroscopy. What is the Mössbauer effect and What is the characteristic feature of Mössbauer spectroscopy? These questions are answered briefly in this chapter. Mössbauer spectroscopy is based on recoilless emission and resonant absorption of gamma radiation by atomic nuclei. Since the electric and magnetic hyperfine interactions of Mössbauer probe atom in solids can be described from the Mössbauer spectra, the essence of experiments, the hyperfine interactions and the spectral line shape are discussed. A few typical examples are also given for laboratory experiments and new nuclear resonance techniques with synchrotron radiation.

Chapter 2 is devoted to chemical applications of Mössbauer spectroscopy, and the authors are Philipp Gütlich and Yann Garcia. They begin with a brief recapitulation of the hyperfine interactions and the relevant parameters observable in a Mössbauer spectrum. The main chapter with selected examples of chemical applications of Mössbauer spectroscopy follows and is subdivided into sections on: Basic information on structure and bonding, switchable molecules, mixed-valence compounds, molecule-based magnetism, industrial chemical problems like corrosion, and application of a portable miniaturized Mössbauer spectrometer for applications outside the laboratory and in space. This lecture ends with an outlook to future developments.

In Chap. 3, Robert E. Vandenberghe describes the applications of Mössbauer spectroscopy in earth science. With iron as the fourth most abundant element in the earth crust, ^{57}Fe Mössbauer spectroscopy has become a suitable additional technique for the characterization of all kind of soil materials and minerals. In this chapter a review of the most important soil materials and minerals is presented. It starts with a description of the Mössbauer spectroscopic features of the iron oxides and hydroxides, which are essentially present in soils and sediments. Further, the Mössbauer spectra from sulfides and carbonates are briefly considered. Finally, the Mössbauer features of the typical and most common silicate minerals are represented. Because the spectral analysis is not always a straightforward procedure, some typical examples are given showing the power of Mössbauer spectroscopy in the characterization of minerals.

Chapter 4 concerns with Fe-based nanostructures investigated by Mössbauer Spectrometry, and the author is Jean-Marc Greneche. For the last two decades, numerous projects and studies were devoted to nanoscience and nanotechnology. The understanding of physical properties requires to correlate the structural, chemical and physical properties of nanostructures. Numerous new characterization techniques appear for the same period to investigate structural properties at local nanometer scale. But further local spectroscopic techniques including zero-field and in-field ^{57}Fe Mössbauer spectrometry have to be used in order to probe surface and bulk structures, to determine the role of surface or grain boundaries in the case of nanoparticles and nanostructured powders and static magnetic properties or superparamagnetic relaxation phenomena in the case of magnetic nanostructures. He illustrates thus how in situ ^{57}Fe Mössbauer spectrometry can be extremely relevant when it is used to investigate local properties of nanocrystalline alloys, nanostructured powders, nanoparticles and assemblies of particles and functionalized nanostructures and mesoporous hybrids.

In Chap. 5, subsequently, Mössbauer studies on magnetic multilayers and interfaces are explained by Teruya Shinjo and Ko Mibu. Mössbauer spectroscopy has been used as a fundamental analytical tool to characterize various magnetic materials. It is described in this chapter that a magnetic hyperfine interaction observed in a Mössbauer spectrum is information particularly useful to investigate magnetic materials. Examples of studies on various magnetic materials utilizing ^{57}Fe and also ^{119}Sn Mössbauer effect measurements are introduced. Modern devices including magnetic materials often consist of multilayered structures and therefore interface properties of ultrathin magnetic layers are of great importance. Mössbauer spectroscopic studies focusing on magnetic properties of multilayers and interfaces are described and unique information obtained from Mössbauer spectra is explained.

Finally, in Chap. 6, Guido Langouche and Yutaka Yoshida provide "implantation Mössbauer spectroscopy" between 1983 and 2011, where three accelerator facilities, i.e., Hahn-Meitner Institute Berlin, ISOLDE-CERN and RIKEN, have been used for materials research. The techniques developed are "Coulomb-excitation and recoil-implantation", "on-line isotope mass separation and implantation" and "projectile fragmentation and implantation", respectively. The physics on dilute atoms in materials, the final lattice sites and their chemical states as well as diffusion phenomena can be studied immediately after each implantation of the nuclear probes. In order to get such atomistic information, however, it is quite important to select a proper system investigated in a research project, and in addition, to consider both the defects produced near the nuclear probes and their motions during the measurements.

In the last few years many leading scientists in our Mössbauer community passed away in different countries: Hendrik de Waard, Uli Gonser, F. E. Fujita, and recently also Rudolf L. Mössbauer, the discoverer of the effect called after him. We all are strongly indebted to their research work which has been challenging during their whole life. We are extremely grateful to them, and we will do our best in transferring their heritage to the next generations of the Mössbauer family.

Fukuro, September 2012 Yutaka Yoshida
Leuven Guido Langouche

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