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“MÖSSBAUER EFFECT AND STUDIES OF SURFACE LAYERS”

(for WEB)

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Preface to WEB edition.

The manuscript “MÖSSBAUER STUDIES OF SURFACE LAYERS” was published at 1993 by “ELSEVIER”. It was prepared as copy ready manuscript in word processor CHIwriter.4. Now the copyright is finished and my wife Ludmila and I converted the CHIwriter version to WORD97 version.

A lot of troubles appears connected first of all with formulas.

The title of the manuscript is slightly changed. Now it is “MÖSSBAUER EFFECT AND STUDIES OF SURFACE LAYERS”. The change in the manuscript is minimal and the number of pages coincide with the number of “MÖSSBAUER STUDIES OF SURFACE LAYERS” published at 1993 by “ELSEVIER”.

I hope that the version will be valuable for peoples which like strike up an acquaintance with Applications as well as Theory Mössbauer spectroscopy.

PREFACE

The study of solid surfaces is one of the most important problems in solid state science. One feature of such studies is the development of techniques which are able to examine solids over a wide range of compositions, gaseous pressures, different temperatures and under conditions of practical interest. The surface of such specimens of interest may be of any shape. It is also important to note that the different fields of science and technology have different notions of what constitutes a surface. For example, a physicist dealing with the interaction of absorbed atoms with the substrate surface means by the latter the actual geometric surface or a layer with the depth of less than 1 nm. A metallurgist's interest in a surface is generally that region of the solid which is tens and hundreds of μm deep. This is one of the reasons why some physics encyclopedia give no definition of a surface.

At this stage it is relevant to note that emission Mössbauer spectroscopy is capable of the examination of 10^{12} atoms implanted on a square centimetre which is equivalent to one hundredth of the number of atoms making up a monolayer on the area of one square centimeter. It is important to note that the technique can investigate the properties of layers which are tens of μm deep. Whilst nuclear physics has developed many novel methods of surface modification (e.g. implantation) and effective nuclear research methods, Mössbauer spectroscopy has developed as one of the few methods available for investigation of solids differing in depth by several orders of magnitude. Hence, it is only in recent times that the problems of surface investigation and the study of separate layers have been amenable to investigation.

Two factors may be identified which are responsible for the widespread use of Mössbauer spectroscopy in both fundamental and applied surface science research. Firstly, the absolute selectivity of Mössbauer spectroscopy which means that in each experiment a response is registered from only one isotope of the element. Furthermore, atoms of that element in non-equivalent positions give different responses with magnitude which is proportional to the populations of the positions. Secondly, Mössbauer spectroscopy has a high sensitivity which is determined by the minimum number of resonant atoms needed to get a detectable response. In the transmission Mössbauer spectroscopy for ^{57}Fe a response is given by a monolayer with the area of the order of 1 square centimetre. However, as has already been mentioned, higher sensitivities can be achieved in emission Mössbauer spectroscopy.

The parameters of the hyperfine interaction derived from the Mössbauer spectra provide valuable information on the chemical bond character and on magnetic properties of surface layers as well as on the change of the properties with the depth from the outermost surface layer. It is possible to carry out quantitative phase analysis and to use the technique to study different transformations in the solid which result from external effects under a wide range of temperatures and pressures. Certain problems are sometimes encountered which are caused by the limited activities of Mössbauer sources and by the rather low cross section of the radiation interaction with matter. However, such problems are compensated by the absence of any limitations on experimental conditions other than that the substance should be a solid. As a consequence, Mössbauer spectroscopy can be used in fundamental research and in various areas of applied science and technology including process monitoring. This book is one of the first attempts at a consistent presentation of theoretical and practical problems of the use of Mössbauer spectroscopy to study solid surfaces, its applications, and development.

The applications include: surface studies with hyperfine probes in the following fields: oxidation and corrosion of metals and alloys; passivating and protective coatings; physics of metals: annealing and quenching, mechanical and chemical treatment, ion implantation and laser treatment; texture of near-surface layers. The choice is based on scientific interests of the author and his practical experience in these fields. However, the limited space does not allow complete coverage of any of the topics mentioned above. It is also important to note some other fields - for example the unique capabilities of Mössbauer spectroscopy for fine particles studies: superparamagnetism, phase analysis and the magnetic structure of the surfaces of particles which may be smaller than 10 nm; the effect of the gas phase on the properties of small particles, the interaction of these particles with the substrate; and the importance of these studies in areas of industrial significance such as catalysis. It should also be noted that Mössbauer spectroscopy is one of the best methods for in situ characterization of solid/solid and solid/solution interfaces. This lends itself to in situ studies of surfaces under various coatings and processes, surface magnetism and the effect of the gas phase on the properties of the surface layers and the structure and magnetic properties of epitaxially grown monolayers on the surface of oriented single crystals .

I wish to thank all the colleagues whose advice made it possible for the final version of the book to be published. I am especially indebted to Professors R.N. Kuzmin, B.S.Pavlov, G.V. Smirnov and Drs A. Dozorov, A. Ryzhkov and V.G. Semenov from Russia, Prof. Ph. Gütlich and Dr. W. Meisel from Mainz University, Prof. J. G. Stevens, Mössbauer Effect Data Center, University of North Carolina, Prof. H. De Waard from the Netherlands and Dr. F. Berry from University of Birmingham (England). I am grateful to A.P. Taranov for the translation of the manuscript and helpful suggestions.

I would like to thank my wife Ludmila Belozerskaya for her patient help with the translation, preparation, typing and retyping of the manuscript.

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