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Interfaces and Thin Films

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Hans Lüth

Solid Surfaces, Interfaces and Thin Films

Fourth, Revised and Extended Edition
With 389 Figures and 13 Tables



Springer

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Preface

Surface physics in the classical sense of ultrahigh vacuum (UHV) based experimental approaches to understand well-defined surfaces has now become a mature branch of condensed matter research. Meanwhile, however, the theoretical concepts and experimental techniques developed in this field have also become the basis for modern interface, thin film and nanostructure science. Furthermore, these research fields are of fundamental importance for more applied branches of science, such as micro- and nanoelectronics, catalysis and corrosion research, surface protection, chemo- and biosensors, microsystems and nanostructured materials.

The physics of solid surfaces, interfaces and thin films is thus an important field which needs to be taught to all students in physics, microelectronics, engineering and material science. It is thus no surprise that this topic has now entered the corresponding university curricula throughout the world.

In the present 4th edition of this book (formerly entitled “Surfaces and Interfaces of Solid Materials”) more emphasis is placed on the relation between the surfaces, interfaces and thin films, and on newly discovered phenomena related to low dimensions. Accordingly, a few topics of the earlier editions that are now only of peripheral interest have been omitted. On the other hand, a new chapter dealing with collective phenomena at interfaces has been added: Superconductor–semiconductor interfaces and thin ferromagnetic films have attracted considerable attention in of late. This is mainly due to our improved understanding of these phenomena, but also to important application aspects which have recently emerged. For example, giant magnetoresistance, a typical thin film phenomenon, is of considerable importance for read-out devices in magnetic information storage. Likewise, ferromagnetism in low dimensions may play an important role in future non-volatile memory device circuits. The corresponding topics have thus been added to the new edition and the title of the book has been modified slightly to “Solid Surfaces, Interfaces and Thin Films”. This new title better describes the wider range of topics treated in the new edition.

Furthermore, in response to several suggestions from students and colleagues, errors and inconsistencies in the text have been eliminated and improvements made to clarity. On the topics superconductor–semiconductor interfaces and ferromagnetism in low dimensions, I have benefited from dis-

cussions with Thomas Schäpers and Stefan Blügel, respectively. The English text was significantly improved by Angela Lahee, who, together with Katharina Ascheron, also contributed much to the final production of the book.

Particular thanks are due to Claus Ascheron of Springer-Verlag, who managed the whole publication process.

Aachen and Jülich
July 2001

Hans Lüth

Preface to the Second Edition

Surface and interface physics has in recent decades become an ever more important subdiscipline within the physics of condensed matter. Many phenomena and experimental techniques, for example the quantum Hall effect and photoemission spectroscopy for investigating electronic band structures, which clearly belong to the general field of solid-state physics, cannot be treated without a profound knowledge of surface and interface effects. This is also true in view of the present general development in solid-state research, where the quantum physics of nanostructures is becoming increasingly relevant. This also holds for more applied fields such as microelectronics, catalysis and corrosion research. The more one strives to obtain an atomic-scale understanding, and the greater the interest in microstructures, the more surface and interface physics becomes an essential prerequisite.

In spite of this situation, there are only a very few books on the market which treat the subject in a comprehensive way, even though surface and interface physics has now been taught for a number of years at many universities around the world. In my own teaching and research activities I always have the same experience: when new students start their diploma or PhD work in my group I can recommend to them a number of good review articles or advanced monographs, but a real introductory and comprehensive textbook to usher them into this fascinating field of modern research has been lacking.

I therefore wrote this book for my students to provide them with a text from which they can learn the basic models, together with fundamental experimental techniques and the relationship to applied fields such as microanalysis, catalysis and microelectronics.

This textbook on the physics of surfaces and interfaces covers both experimental and theoretical aspects of the subject. Particular attention is paid to practical considerations in a series of self-contained panels which describe UHV technology, electron optics, surface spectroscopy and electrical and optical interface characterisation techniques. The main text provides a clear and comprehensive description of surface and interface preparation methods, structural, vibrational and electronic properties, and adsorption and layer growth. Because of their essential role in modern microelectronics, special emphasis is placed on the electronic properties of semiconductor interfaces

and heterostructures. Emphasizing semiconductor microelectronics as one of the major applications of interface physics is furthermore justified by the fact that here the gap between application and basic research is small, in contrast, for example, with catalysis or corrosion and surface-protection research.

The book is based on lectures given at the Rheinisch-Westfälische Technische Hochschule (RWTH) Aachen and on student seminars organized with my colleagues Pieter Balk, Hans Bonzel, Harald Ibach, Jürgen Kirchner, Claus-Dieter Kohl and Bruno Lengeler. I am grateful to these colleagues and to a number of students participating in these seminars for their contributions and for the nice atmosphere during these courses. Other valuable suggestions were made by some of my former doctoral students, in particular by Arno Förster, Monika Mattern-Klosson, Richard Matz, Bernd Schäfer, Thomas Schäpers, Andreas Spitzer and Andreas Tulke. For her critical reading of the manuscript, as well as for many valuable contributions, I want to thank Angela Rizzi.

The English text was significantly improved by Angela Lahee from Springer Verlag. For this help, and also for some scientific hints, I would like to thank her. For the pleasant collaboration during the final production of the book I thank Ilona Kaiser. The book would not have been finished without the permanent support of Helmut Lotsch; many thanks to him as well.

Last, but not least, I want to thank my family who missed me frequently, but nevertheless supported me patiently and continuously during the time in which I wrote the book.

Aachen and Jülich
October 1992

Hans Lüth

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