Book review

Scanning probe microscopy: beyond the images
Edited by S. Gauthier and C. Joachim
Les Editions de Physique (1992)

In the editorial of volume 2, issue 6 of Microscopy, Microanalysis, Microstructures, one year ago, Sébastien Gauthier and Christian Joachim reported about a summer school "Concepts and image interpretation in near-field microscopy" which took place in Oléron, France, during the fall of 1991. They announced the publication of the texts of the lectures as a book to be published by the Editions de Physique.

Twelve months later, the book is now available under its elegant black cover with a nice calculated image of the letters "STM" made from Xenon atoms adsorbed on the (110) face of copper. This image is an illustrative introduction to the basic goal of this school and of the book. It was first to gather theoreticians and experimentalists concerned with the general problem of extracting the physical or chemical information provided by these local probe measurements. The book contains the text of the lectures covering the theoretical basis for the three most developed techniques: tunnel microscopy, force microscopy and near field optical microscopy, and emphasizing the common concepts, the approximations involved and the possibilities offered to interpret the images.

Seven English written chapters, for a total length of 275 pages constitute the bulk of this volume. Three of them are rather general and introduce some fundamental knowledge about surfaces, the tunnel effect and the forces between the surfaces. The other chapters apply more directly to the theory of understanding the data delivered by the three near field instruments under consideration.

In the first category there is the fully documented chapter by Desjonquères and Spanjaard who review the simple schemes (tight binding approximation and effective medium theory) which are currently used to describe various surface phenomena such as relaxation, reconstruction and chemisorption. Klein and Sacks summarize the basic elements required to understand the tunnel effect. The chapter written by Noguera provides an overview of the concepts involved in describing forces between particles and/or macroscopic bodies. It also accounts for the distorsions which can occur when two solids come into close contact and for the eventual presence of a third medium such as water between tip and surface. One easily guesses that such a background is required for anybody who wants to understand how his atom force machine is working.

The three chapters by Sacks, by Girard and Bouju, and by Van Labeke discuss more specifically the models and approaches which have been developed for the three microscopes. For the STM, the well known Tersoff and Hamann theory is introduced as a first step, then the effects of a bias voltage, of the barrier transmission and of the tip-surface electronic interactions are considered. The reader gets a good feeling of the mechanisms involved, both in spectroscopy and

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topography, at least qualitatively. However, it is clear that a quantitative interpretation of the data is not yet available through this approach. To predict and interpret STM images a scattering matrix approach has also been proposed, the principles of which are presented by Joachim in a short formal chapter, but one can regret that no applications for it are shown to illustrate a rather dense text.

As for the AFM, the relevant theoretical chapter deals with the calculation of Van der Waals forces between a corrugated surface and a thin probe tip. Some numerical calculations demonstrate the potential range of applications, such as force maps on the graphite both in the repulsive and in the attractive ranges. The theoretical concepts and models for understanding the operating conditions of the near field optical microscope are fully discussed in the final chapter, which underlines many interesting aspects such as the importance of local and technological parameters: "the shape of the image does not reflect the profile of the sample and depends on the tip-surface distance, on the laser polarization and on the tip radius" and "the resolution is not limited by a fundamental principle like in Far Field microscopy but rather by technological constraints: radius of the apex of the probe, signal on noise ratio".

As a conclusion, this book clearly demonstrates the richness and varsity of the production of a groups of French theoreticians who have collaborated with success to promote a range of complementary tools to understand what you see with your near-field microscope. There does not exist yet well established image simulation programs similar to those currently used in electron microscopy. The instrument is much younger and the first step was to define clearly the concepts, the tools, to identify the problems and limits. Computed images begin to appear for well defined objects and probes. This adventure is a success and for this reason I can fully recommend this book to the newcomers to the field and also to the veterans who wish to refresh their basic knowledge and teach the subject.

PS: This cooperative effort between French theoreticians has been greatly supported by the CNRS interdisciplinary Ultimatech program and I can also advertise for the Ultimatech letter n° 4, october 1992, which contains a full report of 23 pages illustrating many experimental and theoretical aspects in Near Field Microscopy (however written in French). This document can be obtained from Ultimatech, CNRS, Paris.

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