PREFACE

Twenty years ago there was some truth in a joking statement made in an opening address at a solid state chemistry conference; chemists are able to prepare pure, beautifully crystallized samples, but they study their properties by poor primitive methods. Physicists apply sophisticated, highly accurate techniques to investigate any kind of obscure chemical they happen to find in the laboratory.

Twenty years ago it was common practice that solid state physicists and chemists each arranged meetings of their own, and discussions and exchange of ideas between the two groups were rather exceptional.

Twenty years ago the arsenal of techniques for studying the microstructure of solids was very limited. Diffraction methods had certainly been available for a long time and had brought extensive information about crystal structures. A crystal structure, however, even if very accurate, only describes the average arrangement of the atoms in the crystal studied. The only technique available to find the sites of individual atoms in a solid was the field emission method, the applicability of which at that time was limited to studies of metallic materials with very high melting points.

Two decades ago, however, a remarkable development was taking place in electron microscopy. New powerful microscopes and improvements of experimental techniques combined with advances in the analysis of the micrographs made it possible to interpret pictures obtained of some complicated metal oxids in terms of images of crystal lattices, which could be correlated with known crystal structures and could also be used to demonstrate the presence and character of structural defects in the compounds. Such research described in a seminal paper by Allpress, Sanders and Wadsley has since developed in such a way that lattice imaging has advanced to the state of direct imaging of atoms lined up parallel to the electron beam. This is now a powerful and widely applied technique- high resolution electron microscopy (HREM)- for studies of real atomic- level microstructures of solids. Since this important development has taken place over the past twenty years, this seems to be an appropriate time for looking at the area in perspective.

The last two decades have witnessed a remarkable development in a variety of techniques related or supplementary to the imaging of atoms in the electron microscope. One of those achievements has been to complement the electron microscope by means allowing in-situ identification of the chemical nature of atoms. Indeed, the excitation of their deep atomic levels by the incident electron beam leaves in the energy spectrum of the transmitted electrons, a"signature" of energy losses which characterizes the chemical identity of the atoms present in the irradiated volume just like the characteristic lines in an X-ray spectrum. Scanning transmission electron microscopy coupled with electron energy spectrometry makes it possible to obtain "chemical maps" at the nanometer level and, in favourable cases, to identify the chemical nature of clusters of a few atoms. Parallel detection of the energy spectrum is an important step since it results in an appreciable gain in acquisition time, a better precision in background subtraction and a reduction

in radiation damage.

With the "atom probe", field emission microscopy has accomplished a major evolution leading to a powerful tool for determining the chemical identity of atoms in-situ with atomic spatial resolution. This evolution is partly due to the current progress in technology which has produced sophisticated devices like the microchannel plate and also fast electronics, making easier the construction of time-of-flight mass spectrometers compensated for energy dispersion. Presently, it is possible to identify a single atom emitted as an ion by field evaporation from a given site on the surface of a needle-point sample. In parallel, sample preparations have been improved (pulsed electrolytic polishing) so that the applicability of the method is now extended to many metals and alloys. Field evaporation also gives a means for progressively removing atomic layers, allowing an in-depth exploration of the sample. Using electron microscopy on needle-point samples serves to locate areas of interest; segregations at grain boundaries offer striking examples of what can be observed by this combination of techniques.

The study of surface topography and of electronic surface properties at the atomic level has made a remarkable leap forward with the advent of the scanning tunnel microscope, followed a few years later by the scanning force microscope. There is a great deal of activity in building laboratory systems and in exploring applications. Throughout the contributions to this conference, it is interesting to see how the technique is used to examine the build-up of a layer of adsorbed atoms. Although atomic resolution is still stressed as the most important feature, emphasis is also put on the necessity of using a wide field of view by means of large scan windows with a concomitant increase of acquisition time.

The growing interest in microstructure studies has been strongly accelerated by the discovery of new groups of solid materials with unexpected new properties. An extensive exploration of the architecture of compounds exhibiting mixed valence, bidimensionality and superconductivity at high temperatures is going on, in which HREM plays an essential role. Similarly a large variety of quasicrystalline intermetallic compounds have been investigated, in a search for knowledge about the nature (deterministic or random) of the tiling, the thermodynamic stability and possible phase transitions. One of the major points coming out from the discovery of this new state of organization of matter is the following: what we call a crystal is a structure resulting from a long range order organization. As a consequence, translation property is not the only requirement for the building of a crystal. It is also worthwhile to note that high resolution microscopy has been remarkably successful in the study of defects and of their interactions with grain boundaries.

The present conference was arranged to bring together physicists, chemists, metallurgists and other scientists interested in the microstructure of solids. Some of the participants would hardly have met at ordinary scientific meetings. It was gratifying to find that lively discussions took place across the discipline borders and that the very difference in background and experience of the participants did not hinder the exchange of ideas but rather helped to enrich the discussions.

The conference has been a joint undertaking by the Royal Swedish Academy of Sciences and l'Académie des Sciences de l'Institut de France. It is the third meeting on subjects related to solid state research arranged within an agreement on scientific exchange and cooperation between the two academies, signed in May 1983. The two previous ones, on Advances in Powder Diffraction Crystallography, and on Preparation and Property Characterization of Crystalline Inorganic Materials, took place in Stockholm in 1985, and in Saint-Léonard des Bois, close to Le Mans in 1987, respectively. A particular feature of the present conference has been that it, as was the case also with the 1987 meeting, was followed by study visits of the guest participants to laboratories in the host country, selected individually so as to best suit mutual interests.

The conference and the subsequent study tours were organized in a very successful way by a commitee comprising Dr. J.O. Bovin (Lund) and Prof. G. Ferey (Le Mans), L. Kihlborg (Stockholm) and R. Portier (Vitry). In several respects the staff of l'association Franco-Suédoise pour

la Recherche (AFSR) has rendered very valuable assistance in the organizational work.

The conference and the laboratory visits were made possible through the generous support given by the Nobel Institute for Chemistry, the Swedish Natural Science Research Council (NFR), the Fund in Memory of the Brothers Jacob and Marcus Wallenberg, and the Centre National de la Recherche Scientifique (CNRS).

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