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Edited by P Doig

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Preface

The published EMAG 83 Proceedings of the Electron Microscopy and Analysis Group biennial meeting provide the reader with up to date information on recent developments in electron microscopical techniques and their applications. The success of these meetings, which provide an opportunity for the exchange of information, ideas and experiences, is evidenced by the numbers attending and the quality of their contributions.

The papers presented by the sixteen invited speakers drawn from the UK, USA, France and Japan were the backbone of the meeting. There were fourteen sessions, covering instrumentation, electron–specimen interaction, signal detection, image processing, improvements in the existing techniques, new techniques and applications of electron microscopy to metals, ceramics, polymers, chemistry and semiconductors. As more than thirty authors wished to present their work as posters, there were two poster sessions. This interest shows that some work is more suitable for this type of presentation and usually leads to extensive discussion. This is a new feature of the EMAG meetings and is likely to be repeated in the future. The order of the sessions was dictated by the time available for presentation of the papers and an attempt to avoid an overlap of the invited talks and related subjects when two sessions were in parallel. The papers appear in their chronological order, inserting contributions to the poster sessions where appropriate.

The first session, as at the previous meeting, was devoted to electron beam damage. In comparison with previous years there was a strong shift towards quantitative measurements and more detailed understanding of the chemical reactions during irradiation. Some of the beam damage characteristics were utilised for analytical purposes and for lithography. The session on the diffraction techniques was dominated by papers on the elegant and accurate convergent beam diffraction technique. There were some very good examples of its application to the crystallographic analysis of very small volumes. The session on X-ray spectroscopy was concerned primarily with the analysis of data, rather than development of the techniques. The X-ray analysis, together with the detection of other signals for analysis, was summarised in the introductory talk to the session on microanalytical electron microscopy. This session included a review paper on electron energy analysis and several contributed papers on Auger analysis and cathodoluminescence. It is interesting to note that, as with X-ray analysis, the emphasis was more on the interpretation of data than on the construction and properties of spectrometers; indicating that these techniques have now reached a more advanced state of development. It seems that high resolution electron microscopy does not enjoy the novelty of the previous years and has become a more routine technique for obtaining information on arrangements of atoms in the material. The importance of combining the high resolution studies with analytical techniques and image processing was emphasised in the introductory talk to the high resolution session. There was a short session on the study of magnetic structures and ferromagnetic layers, in which some very good contrast techniques were described. As in the last EMAG meeting, one

afternoon session/workshop was devoted to the discussion of a rapidly developing field, viz surface studies introduced by Professor Castle, who also coordinated the discussion. The subject of this year's session was surfaces, and was introduced and coordinated by J E Castle. The session on data collection and image analysis dealt mainly with numerous computer techniques. The advantages of the scanning systems for this application were very obvious. One or two microcomputers now form an integral part of a modern electron microscope and it seems that the expensive and inefficient image intensifiers are now things of the past. The four sessions on the applications of electron microscopy contained papers which describe the use of one or more techniques, often in a very original and ingenious way, for solving a particular problem. The session on catalysis and chemistry contained some very high quality papers, solving complex and difficult problems of studying the details of very fine surface morphology. Application of the electron microscopy to metals was, as usual, the largest session. The small scale texture studies, fine details of interfaces, the nature of small defects and fine dispersion of phases all provided excellent examples of an approach involving full utilisation of many techniques which high quality electron microscopy can offer. The study of metal and metal oxide films requires special techniques of specimen preparation and some progress in their development was reported. The electron miroscopy of ceramics also seemed to be limited by the availability of the specimen preparation techniques. Nevertheless some good papers on the structure of ceramics, minerals, oxides and corrosion scales were presented. The session on the electron microscopy of semiconductors was introduced by an excellent survey of techniques and basic problems and continued with papers on structure and defects in semiconductor devices. The main technique is scanning electron microscopy with a number of analytical techniques including those for electro-active materials. The last session on the electron and ion optics contained a description of some novel techniques; in particular the ion source microscopy and lithography, low voltage scanning electron microscopy, scanning electron acoustic microscopy and scanning electron optical microscopy. This provides the reader with evidence that the dynamic and exciting search for new and/or more accurate information about the specimen is as lively as ever.

The papers in this volume contain only the scientific data, and it may be useful for those readers, who were unable to attend the meeting, to describe the circumstances under which they were presented. The meeting was organised at the pleasant and compact campus of Surrey University close to Guildford town centre. Thanks to the continuous and enthusiastic effort of P Goodhew, the local committee chairman, and his co-workers, everything ran very smoothly. The three nice hot summer days were packed with activities. The parallel sessions were well attended; inevitably some of the participants regretted that it was not possible to participate in both. The large exhibition, which was opened with a social evening, was very impressive including new equipment and facilities. The contrast between this modern equipment and that used 30 to 50 years ago was highlighted in the admirable lecture by V E Cosslett entitled: 'The history (and pre-history) of electron microscopy in Britain', in the course of which he talked about, with the aid of early photographs, the pioneers of electron microscopy and the apparatus with which they worked. It was entertaining and educational and certainly conveyed a notion of the enormous progress made in

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recent years. The meeting culminated with the conference dinner held in an old malt house at Farnham, the atmosphere of which, coupled with folk music and good beer, evoked the feeling of a seventeenth century village.

In short, it was a good meeting which we shall remember and hopefully the reader will find its results in this Proceedings useful and full of stimulating ideas.

D Vesely
Chairman, Programme Committee

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Radiation damage in the electron microscope: bane or boon?

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In some sense, one's reaction to radiation damage in the electron microscope is similar to the reaction to the "energy crisis"--it is generally ignored until it becomes bothersome. After all, it is not the main item on the microscopist's agenda, but rather happens to be an unfortunate consequence of viewing the sample. The question that is usually asked is: how can one reduce the damage in the electron microscope to acceptable limits? Over the last decades, various methods have been suggested and proved promising in allowing us to study sensitive materials: 1) cooling the object (for recent compilations see E. Zeitler, 1982), 2) impregnating or encapsulating the object with a substance that makes the object less destructable (e.g., Fryer and Holland, 1983; Salih and Cosslett, 1979) and 3) using as few electrons as possible in obtaining an image or spectrum (e.g., Williams and Fisher, 1970). It is perhaps interesting to note that all these avenues were suggested almost a half century ago! (L. Marton, 1934.)

These approaches, however fruitful, still sidestep the issue--that there is inherent damage to the sample due to the fact that in the electron microscope one is using a highly ionizing radiation probe. The problem of damage is now not limited to only biologists and polymer scientists, where doses of the order of electrons/Å^2 (1.6 mcoul/cm^2) of 100 keV electrons are sufficient to destroy long range order and even result in loss of material (see Table I). It also shows its head when one tries to extract elemental and chemical information from nanometer size areas of samples normally thought of as being relatively radiation resistant.

Since the detected signal is proportional to the number of analyzed atoms times the irradiation dose, the dose needed to extract information increases as we go to ever smaller probed volumes. For example, a dose of about 10^7 electrons/Å^2 of 100 keV electrons is needed to reliably detect about 100 oxygen atoms using the K shell excitation edge of oxygen and electron energy loss spectroscopy (Isaacson, 1979), whereas recent experiments on the detection of oxygen in dislocation cores of germanium have shown oxygen desorption at doses of about 10^6-10^7 electrons/Å^2 (Bourret et al., 1983). Thus, radiation damage is becoming a more visible problem throughout electron microscopy, now that we have tools to ask more sophisticated questions.

As E. Zeitler (1981) pointed out in the same role at the EMAG conference two years ago, it is becoming increasingly clear that we must at least try to come up with some reasonable understanding of the mechanisms of damage rather than descriptive cataloging, if we ever hope to alleviate

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