RECENT DEVELOPMENTS IN THE APPLICATION OF LIQUID METAL ION SOURCES TO SIMS
A. Waugh, A. Bayly, M. Walls, P. Vohralik, D. Fathers

To cite this version:

HAL Id: jpa-00225652
https://hal.archives-ouvertes.fr/jpa-00225652
Submitted on 1 Jan 1986

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
RECENT DEVELOPMENTS IN THE APPLICATION OF LIQUID METAL ION SOURCES TO SIMS

A.R. WAUGH, A.R. BAYLY, M. WALLS, P. VOHRALIK and D. FATHERS

VG Scientific Ltd., Imberhorne Lane, GB-East Grinstead, RH19 IUB, W Sussex

Abstract—High-brightness liquid metal ion sources (LMIS) allow SIMS microprobe analysis with 50 nm spatial resolution at current densities > 1 A/cm². Chemical imaging of matrix and trace elements on the submicron scale is now achieved using a digital image storage system, allowing picture processing and direct comparison of SEM and SIMS images using colour overlays. While high-sensitivity quadrupole mass spectrometers have been developed for SIMS imaging, the ultimate in sensitivity requires magnetic or time-of-flight mass spectrometers.

I - INTRODUCTION

SIMS microprobe analysis is now readily achieved using Liquid Metal Ion Sources (LMIS) to produce the primary ion beam. The high brightness and small source size of the LMIS permit the formation of high-intensity probes (≈ 1 A/cm²) with sub-micron diameters at energies from a few keV up to > 30 keV. These ion probes allow the acquisition of ion-induced secondary electron images and mass-resolved secondary ion images with spatial resolution approaching 50 nm. SIMS imaging has proved to be possible with a very wide range of samples—from metals and integrated circuits to polymers and biological samples. It has proved exceptionally useful on multitechnique systems with samples for which Auger Electron Spectroscopy is difficult due to charging, low sensitivity, or excessive analysis time. SIMS images of elements with average sensitivity are typically acquired in a few tens of seconds.

II - PRESENT INSTRUMENTATION

The present authors have used a number of different 10 kV and 30 kV columns with gallium LMIS sources, and a 10 kV column using a caesium LMIS. SIMS analysis has been achieved using a high-performance quadrupole mass spectrometer (MM12-12): this has recently been increased in sensitivity by the addition of emittance-matching ion optics. A scintillator and photomultiplier are used for secondary electron detection, and a slow-scan display oscilloscope and camera have been employed for image recording up till a few months ago.

Article published online by EDP Sciences and available at http://dx.doi.org/10.1051/jphyscol:1986219
III - DIGITAL FRAME-STORE IMAGE RECORDING

In order to make most effective use of the SIMS imaging technique a fully-digital imaging system based on a DEC PDP-11 computer and a digital frame-store (512x512x8 bit) has recently been developed. The store can be used to hold both SIMS and SEM images, and a removable Winchester disk is used for permanent storage. The system provides the ability to manipulate and combine images, to annotate and provide hardcopy (in full colour) and to provide post hoc analysis in the form of linescans, depth-profiles, images corrected for topographic effects on sensitivity, and image sections at angles other than parallel to the original sample surface.

The frame-store allows the data-recording process to be decoupled from the photographic hardcopy processes. The data is viewed (at constant brightness) during acquisition and the acquisition process is terminated once the signal-to-noise ratio in the image is satisfactory (typically after one minute). Once acquired, images can be digitally processed by such operations as smoothing, edge enhancement, intensity scaling, two-dimensional derivatives, software zoom and rotation, and colour slicing. Perhaps the most useful operation of all is the ability to combine different images as colour overlays. This allows SIMS images at different masses or a SIMS image and a reference image such as a secondary electron image to be compared: this allows the precise localisation of trace amounts of contaminants relative to the physical structure of the specimen surface, for example.

To illustrate this, Figure 1 shows a) the ion-induced secondary electron image of woven 10 um diameter PET fibres, and b) the same image with a colour overlay of the $^{28}$Si$^+$ SIMS from a silicone oil lubricant, trapped between the fibres during processing.

Another possibility with the frame-store not readily achieved by other techniques is the ability to combine images from different depths in the sample to give images of sections not parallel to the original sample surface. Figure 2 shows an example of this. The sample was a 500 A layer of aluminium on PMMA, with 2 um bars cut away from it at 8 um spacing. Some 80 consecutive $^{27}$Al$^+$ ion images were recorded as the sample was sputtered away. The top half of Figure 2 is parallel to the original surface, while the bottom is a vertical section (1000A deep) into the surface, showing the aluminium layer clearly.

IV - SUMMARY AND FUTURE DEVELOPMENTS

The gallium LMIS has proved rugged and reliable in everyday use: LMIS sources using the more reactive caesium, which provides equally good imaging and excellent negative secondary ion yields, are still under development to ensure ease of handling and long-term reliability. To record efficiently the small number of secondary ions from areas as small as 50nm$^2$ on the sample surface very efficient secondary ion optics have been developed and added to the MM12-12 quadrupole. Further gains in sensitivity can be achieved using a magnetic-sector mass spectrometer; for ultimate sensitivity a time-of-flight mass spectrometer is required and an instrument based on the energy-compensated (Poschenrieder) spectrometer used in the VG Scientific FIM 100 Atom-Probe is currently under development.

REFERENCES

Fig. la - Ion-induced secondary electron image of 10 μm polyethylene terephthalate (PET) fibres woven into a fabric.
Fig. 1B - The SEM image of Fig 1a with the $^{28}\text{Si}^+$ SIMS image overlaid.

Fig. 2 - Composite three-dimensional $^{27}\text{Al}^+$ image of a 500Å thick Al test pattern.