

AES studies of the active surface in MCP channels*

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A microchannel plate (MCP) is a parallel array of single electron multiplier channels made of a special type of glass. A high electric field applied across the channels helps to direct electrons through channels where electron multiplication is achieved by secondary emission from the channel walls. A detailed investigation of active surfaces of the channels before and after ageing was performed by Auger Electron Spectroscopy (AES). Depth profiles of surface layers about 30 nm thick inside the channel were obtained. The depth profiles of the samples unexposed and exposed to ageing in an image tube revealed the presence of following main glass constituent elements: Si, O, K, Pb, Ba and low contamination of C. The ionic diffusion process occurring in the active surface of the channel during ageing, causes an increase of the K concentration on the surface and levels the concentration of other elements beneath the surface.

1. Introduction

A microchannel plate is a sheaf of uniformly fused lead glass channels. These channels, especially the composition of their active surface, are responsible for the electrical characteristics of the microchannel plate^{1,2}. A detailed account will be given of the performed work using Auger Electron Spectroscopy (AES). To know the essential differences in the elemental composition of the glassy layers inside the channels of the fresh and aged MCP, depth profile analysis of the surface layers was applied. This method gives the possibility of establishing various glass constituents and follow their distribution by depth profiling of the active surface before and after the ageing of a MCP sample.

2. Experimental

Two VARIAN microchannel plates were investigated. The first was examined before and the second after ageing (electron scrubbing) in the image tube. The samples of MCP were broken along microchannels and separately implanted into the pure indium substrate. The cleaved surface of the sample is shown in a SEM micrograph (Figure 1). The samples were analysed with a scanning Auger microprobe (Physical Electronics Ind SAM 545 A). A static primary electron beam with 5 keV energy, 0.5 μ A beam current and about 10 μ m diameter was used. The electron beam incidence angle with respect to normal to the average surface plain was 30°. The samples were ion sputtered with two symmetrically inclined beams of 1 keV Ar⁺ ions, rastered on a surface area larger than 5 × 5 mm at an incidence angle of 47°. A sputter rate of about 1.5 nm min⁻¹ was determined on a standard multilayer Cr₇Ni thin film structure³. In depth profiles the peak-to-peak intensities of the corresponding Auger transitions are given in normalized relative units.

3. Results and discussion

Depth profiles of the elemental composition of both investigated active layers are similar and reveal the presence of glass constituent elements: Si, O, K, Pb, Ba and C. The surface layers were examined to a depth of about 30 nm. The depth distribution of constituents of the unaged active surface inside the channel is shown in Figure 2. The surface is composed of Si, O, K and Pb. The quantity of C on the surface presents a relatively low contamination, and its concentration decreases quickly to negligible amounts. The Pb concentration is very high on the surface.

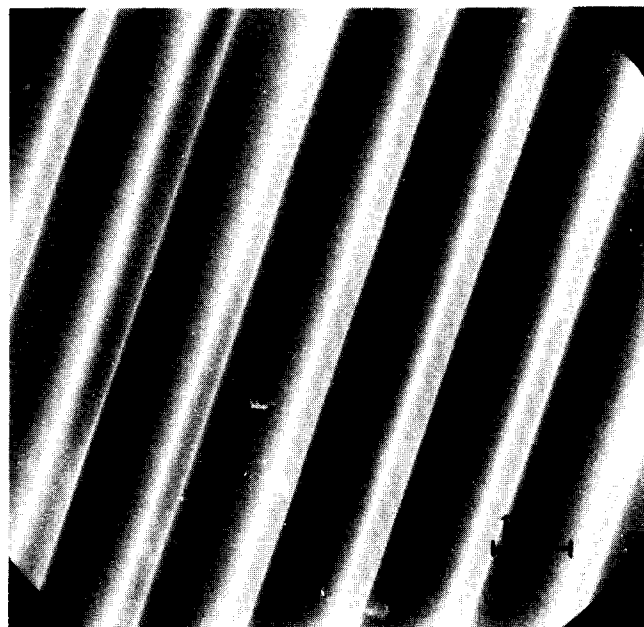


Figure 1. SEM micrograph of the cleaved MCP along microchannels.

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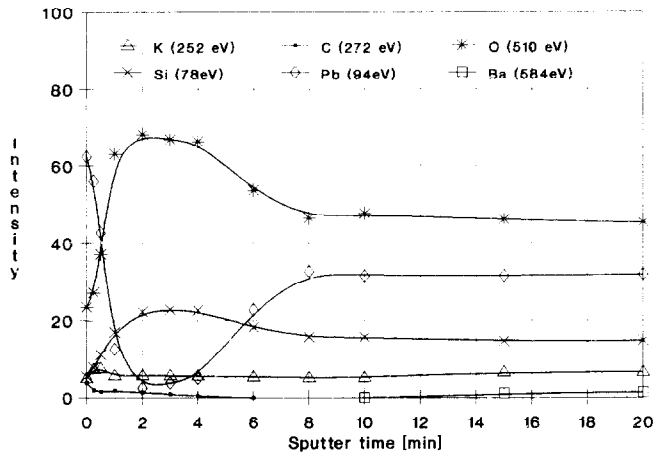


Figure 2. AES sputter depth profile of the active surface of the channel before ageing of MCP.

while in the layer about 10 nm under the surface the Pb concentration is considerably reduced. In the same depth an increase of Si and O was observed. The significantly reduced Pb amount in the mentioned region is caused during the final stages of chemical processing in manufacturing technology. Pb is leached off from a thin layer under the surface deliberately and consequently this layer is enriched with Si and O. In the near-surface region a sudden increase of the K concentration was observed. On the surface and beneath the mentioned region the K concentration is almost the same as in the bulk material. The presence of Ba was observed at a depth of about 15 nm beneath the surface, and its concentration increases slowly in the bulk material. The distribution of the present elements vs sputter depth of the exposed sample (Figure 3) shows that on the surface the K concentration is rather increased, while the Pb concentration is significantly reduced, and C contamination seems to be higher in comparison with the unexposed sample. The thin layer beneath

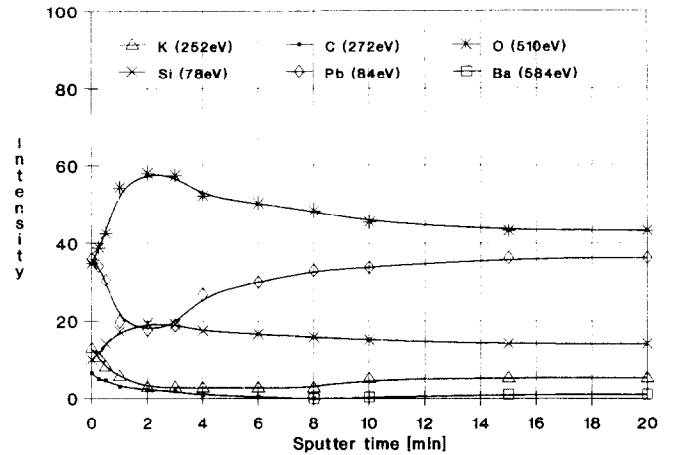


Figure 3. AES sputter depth profile of the active surface of the channel after ageing of MCP.

the surface of the aged sample is enriched with Pb. The discovered increase is probably due to an ionic diffusion process of Pb.

4. Conclusion

The composition of fresh and aged active surfaces of MCP channels was investigated by AES. The concentration of elements in the active surface of the fresh and aged samples is different in comparison with the base glass. During ageing the diffusion processes level the concentration of all the present elements except that of K. The concentration of K on the surface increases with respect to its content in the base glass.

References

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