Reduction of Matrix Effect in ToF-SIMS Depth Profiling via H_2 Flooding

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Keywords: H_2 atmosphere, SIMS depth profiling, matrix effect, cluster ions

Abstract

The influence of the flooding gas during ToF-SIMS depth profiling was studied to reduce the matrix effect and improve the quality of the depth profiles. The profiles were measured on three multilayered samples prepared by PVD. They were composed of metal, metal oxide, and alloy layers. Thickness of the layers for different samples was between 3 and 30 nm. Dual-beam depth profiling was performed with 1 keV Cs^+ and 1 keV O_2^+ sputter beams and analysed with a Bi^+ primary beam. The novelty of this work was the application of H_2, C_2H_2, CO, and O_2 atmospheres during SIMS depth profiling. Negative cluster secondary ions, formed from sputtered metals/metal oxides and the flooding gases, were analysed. A systematic comparison and evaluation of the ToF-SIMS depth profiles were performed regarding the matrix effect, ionization probability, chemical sensitivity, sputtering rate, and depth resolution. We found that depth profiling in the C_2H_2, CO, and O_2 atmospheres has some advantages over UHV depth profiling, but it still lacks some of the information needed for an unambiguous determination of multilayered structures. The ToF-SIMS depth profiles were significantly improved during H_2 flooding in terms of matrix-effect reduction. The structures of all the samples were clearly resolved while measuring the intensity of the $M_nH_m^-$, $M_nO_m^-$, $M_nO_mH^-$, and M_n^- cluster secondary ions. A further decrease in the matrix effect was obtained by normalization of the measured signals. Improvement in depth resolution as well as reduction of surface roughening during depth profiling were also observed during H_2 flooding. The use of H_2 is proposed for the depth profiling of metal/metal oxide multilayers and alloys. Our results were recently published in the article titled "ToF-SIMS Depth Profiling of Metal, Metal Oxide, and Alloy Multilayers in Atmospheres of H_2, C_2H_2, CO, and O_2" [1].

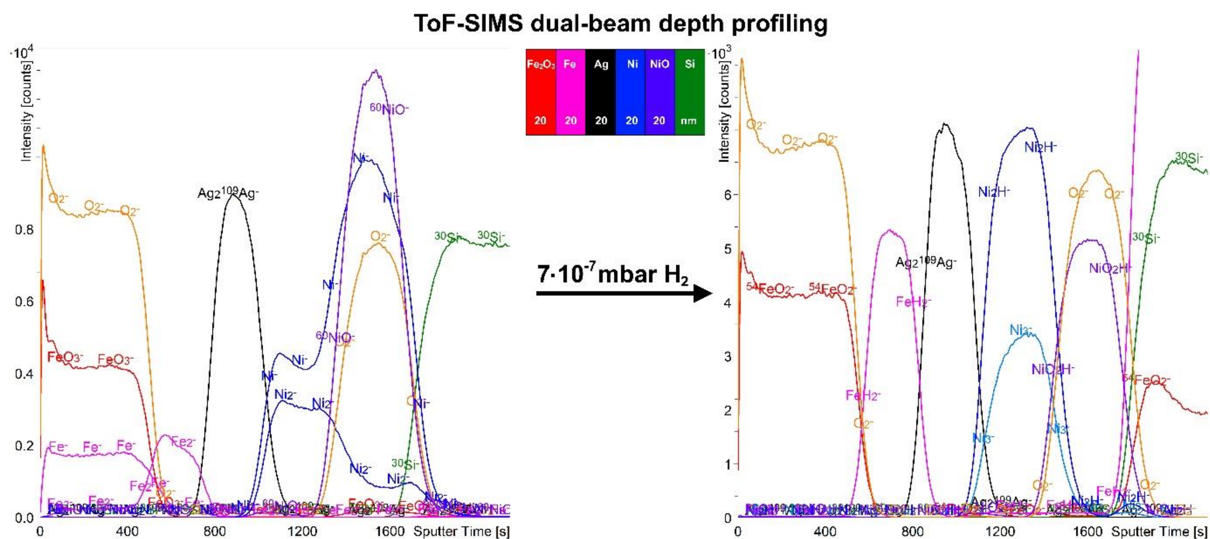

Figure 1: Comparison of the ToF-SIMS depth profiles of the sample composed of the metal and metal oxide layers measured in the UHV environment (left) and H_2 atmosphere (right). Depth profiling was done with the 1 keV Cs^+ ion beam. Pressure during H_2 flooding was 7×10^{-7} mbar and 2×10^{-9} mbar for the UHV conditions.

References

[1] Ekar, J.; Panjan, P.; Drev, S.; Kovač, J. ToF-SIMS Depth Profiling of Metal, Metal Oxide, and Alloy Multilayers in Atmospheres of H_2, C_2H_2, CO, and O_2. *J. Am. Soc. Mass Spectrom.* **2022**, *33*, 31–44.

Acknowledgements

We thank Prof. Peter Panjan for the preparation of the model samples and Prof. Siegfried Hofmann for suggestions for the TiSi sample structure and composition. This work was supported by the Slovenian Research Agency (ARRS) through the Program P2-0082.