Imaging on μXPS, Beamline 7.3.1.2: Resolution and Contrast

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The maximal resolving power available from any imaging system is a function of the point spread function of the system (the "resolution"), the contrast of the feature being imaged, and the statistics of the image.

For the μXPS endstation, the point spread function is determined by the x-ray spot profile. Knife edge measurements give widths of ~1-2μm (FWHM), and the smallest features measured (Au colloid clusters/carbon) were 1x2μm.

Contrast is determined by imaging mode and the composition and structure of the sample. Secondary electron detection (electrons inelastically scattered to low energies) has the advantage of high signal and a weak dependence on the details of surface charging. Measurement of the core photoelectron intensity is specific to the species of interest and has the advantage of high contrast and specificity but has the disadvantage of strong dependence on surface charging and much lower count rates. We have been focusing on secondary electron detection to utilize high count rates, pending improvements in sample charge compensation.

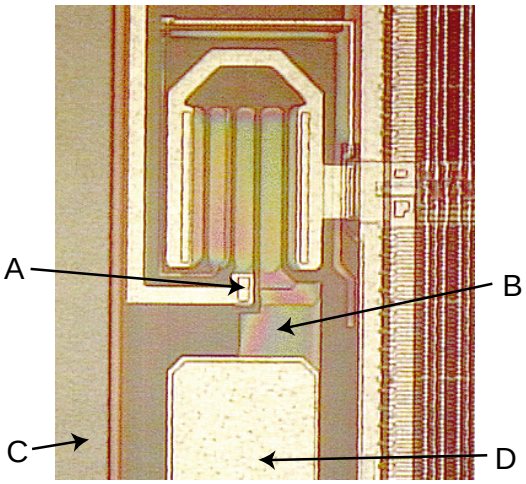
Image statistics are determined by the detector efficiency and the total x-ray exposure which is limited by sample damage considerations.

To examine the practical implications of these factors, we investigated typical microstructure samples from the electronics industry as well as small particles[1]. Figure 1 shows optical and x-ray images of a region around a transistor connected to a row bus in a memory structure. To give scale to the images, the width of the via (labeled A) is 15 μm, and the lines in the memory array on the right hand side are 3-4 μm wide separated by 4 μm spaces.

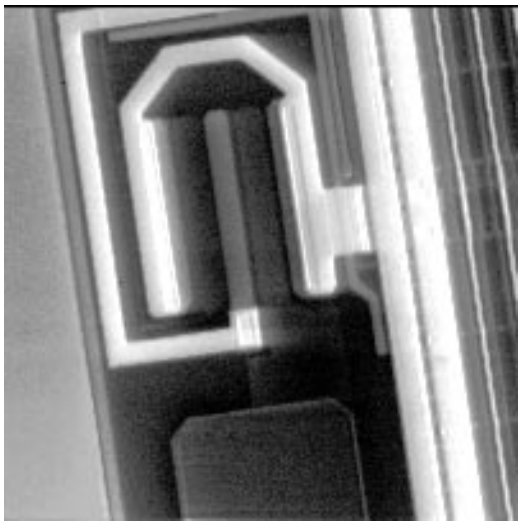
Of particular interest are the sources of contrast in the x-ray image. The bright bars are aluminum metallization grounded to the sample mount. Several vias down to lower levels of the metallization are visible, the brightest being feature A. These vias are visible due to topological contrast derived from the details of the x-ray and detector geometry. The angle between the detector and the x-ray beam is 60 degrees and is bisected by the surface normal. What is surprising is the darkness of the aluminum bond pad (feature D) and the visibility of the metallization underneath the oxide layer (feature B). Looking at the XPS spectra of these regions illuminates the mechanism, i.e. the secondary yield is being modulated by charging of the floating metallization of the bond pad and the oxide over the metallization. The oxide not over metallization charges to an even higher voltage.

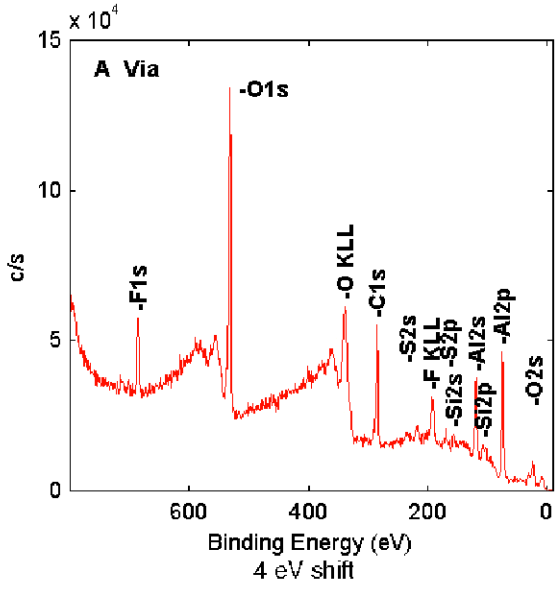
Finally, feature C, an isolation region etched to the underlying silicon, shows the splitting of the Si2p as expected for native oxide on silicon. This shows that on non-charging regions we have sufficient energy resolution to permit chemical state identification.

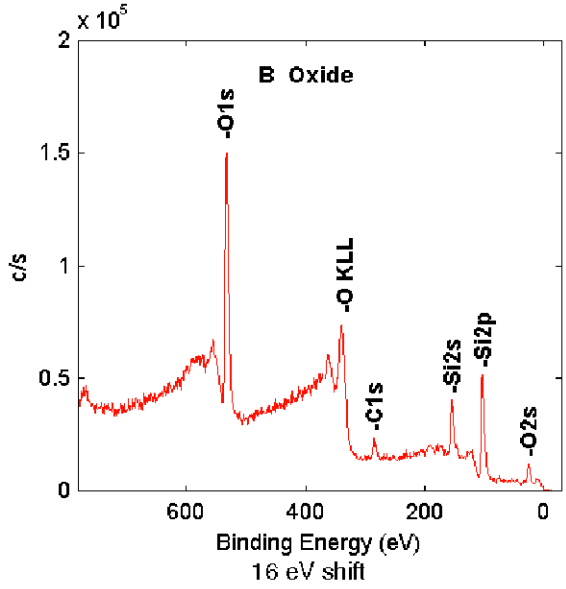
Optical Micrograph

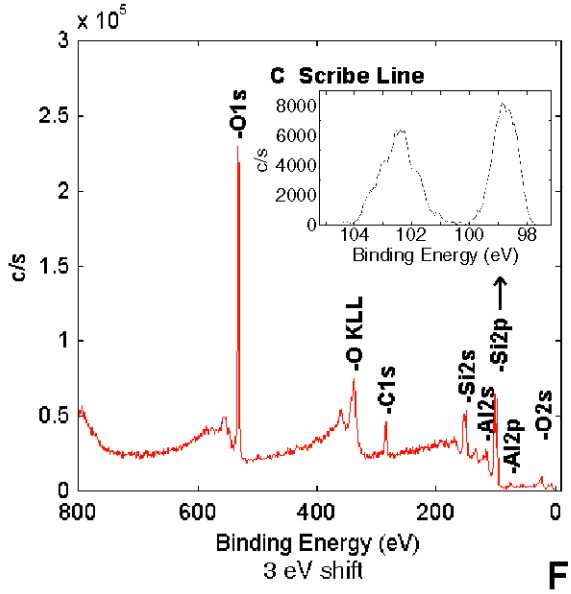


X-Ray Micrograph









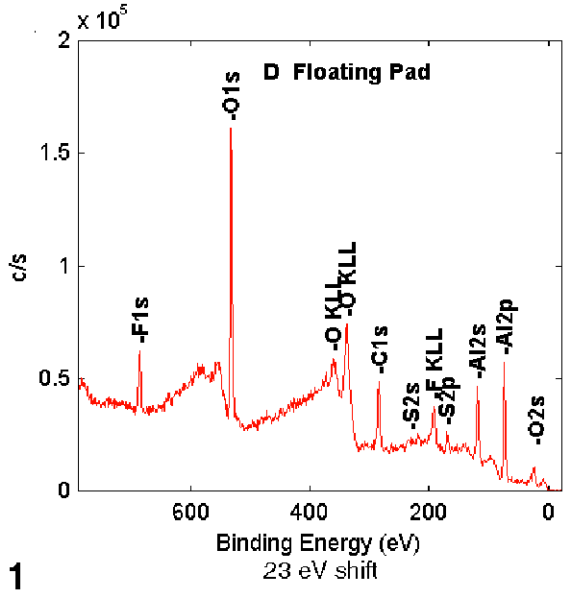


Figure 1

In summary we demonstrate:

- Resolution of features in the several micron size range.
- Microprobe XPS of those features.
- Imaging of samples of industrial interest, with surprising detail.

ACKNOWLEDGMENTS

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REFERENCES

1. F. Gozzo, B. Triplett, R. Ynzunza, P. Coon, C. Ayer, R. D. Kinney, Y. S. Uritsky, G. Ackermann, A. Johnson, H. Padmore, T. Renner, B. Sheridan, W. Steele, and Z. Hussain, Proceedings of the 1998 MRS Spring Meeting, San Francisco, CA (in Press)

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