How is it possible to obtain buried interface information through very thick films with hard X-Ray PEEM?

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It has recently been reported that a hard X-Ray PEEM can be used to image interface structures buried under cover films as thick as 50 nm [1]. Patterns with a lateral resolution of the order of 100 nm have even been observed through films as thick as 200 nm[2]. These results are somewhat unexpected since the escape depth of the image-producing low-energy secondary electrons is limited to about 10 nm. High energy primary photoelectrons, however, carry the information from deeper layers to the surface. On their way they lose their energy continuously through the excitation of plasmons and interband transitions of valence electrons. Those excitations which are produced in the thin surface layer finally decay into the low energy secondary electrons observed in PEEM imaging.

We have analyzed this process in detail by measuring the penetration of Si 1*s* electrons excited by 8 keV X-Rays through a thick Al overlayer film [3] at beamline BL29XU of SPring-8. Hard X-Ray photoemission spectroscopy provides bulk-sensitive information. While the primary Si 1*s* electrons were barely detectable since the Al film thickness exceeded even the mean free path of the 6 keV photoelectrons, strong peaks at energies corresponding to several plasmon excitations were observed. Those plasmons which are produced and decay in the surface layer will provide secondary electrons. Heavier metals deposited at the Si/Al interface will generate a higher flux of fast primary electrons which then produce even more plasmons in the surface layer. Ultimately after their decay this generates the positive contrast observed in the hard X-Ray PEEM.

[1] T. Wakita et al., Jpn. J. Appl. Phys., 45 (2006) 1886.
[2] Presentation by K. Ono at LEEM-PEEM-IV conference at Enschede (2004).
[3] W. Drube et al., to be published.