Visualization of buried interfaces by X-ray reflectivity imaging

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The unique molecular and atomic features of the buried interfaces play vital roles in various systems as diverse as the electrochemical processes, the adhesive strength, the corrosion of a structural metal, and so on. Visualization of those buried interfaces is of great importance, thus imaging capabilities are essential for modern interfaces characterizations. Based on image reconstruction scheme ¹ and X-ray reflectivity technique ², we have successfully visualized hetero structures in buried interfaces by our original non-contact X-ray reflectivity (XRI) imaging system ³-⁶.

Figure 1 shows an example of XRI visualization of a buried interface. The sample was prepared by sputtering a gold layer on a silicon substrate covered by a patterned mask, followed by sputtering a uniform copper layer, as shown Figure 1a. The optical image of the pattern before coating the homogeneous copper layer is shown in Figure 1b.6. The physical meaning of a reconstructed XRI image is a 2D X-ray reflectivity distribution of the sample at specific wavevector transfer Qz. Figure 1b.1 shows the reconstructed XRI image at Qz = 0.024 Å⁻¹. At this Qz, X-rays only reach at the surface, the image shows homogeneous contrast. Figure 1b.2 shows the image at Qz = 0.049 Å⁻¹. We can see a weak contrast of the pattern (or buried gold layer) with other parts. Figure 1b.3 and 1b.4 display images at Qz = 0.057 Å⁻¹ and 0.073 Å⁻¹. This region corresponds to the 1st fringe region of the copper layer, and the reflectivity changes sinusoidally. At these Qzs the buried copper/gold interface is strongly enhanced, and imaging at such Qzs can effectively probe the interface properties. Figure 1b.5 shows the image at Qz = 0.098 Å⁻¹. At this Qz, the patterns have a bright halo structure, which correspond to the differences in thickness inside the gold film. Imaging at such Qzs can be applied to detect differences in the buried layer’s structure such as roughness and thickness with sub nanometers sensitivity. On site, more interesting examples will be demonstrated.

References: