A charge particle simulation study on how well can X-ray PEEM image a buried object

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Abstract

Photoemission electron microscope (PEEM) creates full field images of photoelectrons emitted from the sample surface with a cathode lens. By treating sample as the cathode, an acceleration field is established between the first electrode of objective lens and the sample surface to collect photoelectrons with an enlarged numerical aperture. In general, photon sources such as UV-light and X-ray can be used as the excitation sources for PEEM imaging, but, when the objects of interest are buried underneath a surface, X-ray, which has longer penetration depth, should be adopted. One major problem in imaging buried objects with PEEM is that, before being collected by PEEM, photoelectrons have to propagate to sample surface and to conquer the energy barrier at sample surface to escape into vacuum. As a result, the electron emission profile seen by PEEM is not the original one but the one gets modified by inelastic scattering inside sample and refraction at surface. To make things worse, the degree of modification is not an invariant but varies with object's burial depth, kinetic energy of electron, and energy barrier (work function) of the sample surface [1]. In this study, we first numerically calculated buried object's emission profiles at sample surface, followed by a charged particle simulation using the objective lens designed for PEEM2/3 microscope at Advanced Light Source (ALS)[2]. Our results show that the deeper an object is buried, the lower intensity would the emission profile exhibits. On the other hand, the corresponded emission angles are calculated under the condition of momentum conservation in the direction parallel to sample surface. Finally, charged particle simulation is performed to examine how the unavoidable lens aberrations would degrade the images, and how the degree of improvement a contrast aperture can provide. Fig.1 below illustrate our selected calculation/simulation results.

Keywords – Photoemission electron microscope (PEEM), X-ray PEEM

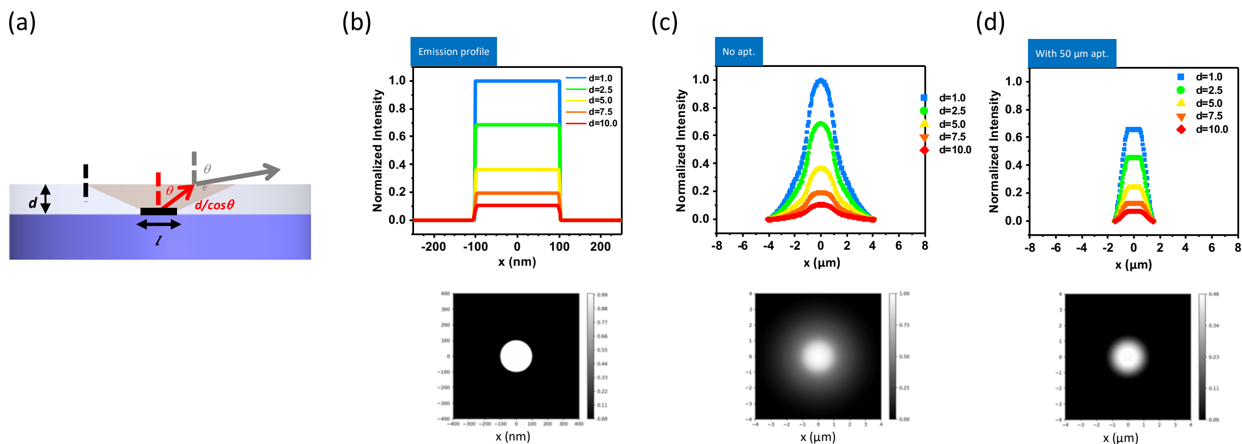

Fig. 1 (a) Illustration of the path of a photoelectron (with an emission angle θ) coming out of the buried object (length = l) with a burial depth d. The photoelectron with sufficient kinetic energy can escape into vacuum at sample surface with a refraction angle (θ_e). (b) The numerically calculated emission profile of a 200 nm buried object, with d = 1– 10 nm. Charged particle simulation of PEEM image (10x magnification) of the buried object, (c) without a contrast aperture and (d) with a 50 µm contrast aperture.

References

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