強度輸送方程式を用いた界面ポテンシャルの計測

Measurement of interfacial potential using transport of intensity equation

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The measurement of potential distribution at a two-phase interface like p-n junction, electrical double layer and electrode/electrolyte interface in batteries, is very important for understanding material's physical and chemical properties. Electron holography is presently the most popular method to obtain local potential distribution, but it needs a biprism as a tool and a vacuum region for observation. Instead, transport of intensity equation (TIE) does not require these. TIE needs only three TEM images taken at different focus settings to calculate the phase shift from the intensity variation along beam direction. This method has been demonstrated useful in measuring the phase shift of metallic nanoparticles absorbed on amorphous thin film. But it was rarely applied to specimen interface. In this study, we proposed a practical procedure for retrieving the phase shift at an amorphous germanium (a-Ge) thin film and vacuum interface based on the TIE to obtain the interfacial potential.

Three steps are found to be necessary to retrieve the phase shift at the interface. First, small regions were selected in the original TEM images to avoid phase modulation caused by low frequency noise. Second, the selected TEM image and its three reflected images were combined for mirror-symmetry to maintain the intensity conservation law. However, in this symmetrization, extra phase modulation arose due to the discontinuous nature of Fresnel fringes at the boundaries between the four parts of the combined image. Third, a corrected phase map was obtained by subtracting a linear background from the original one. The linear background was determined by fitting the phase modulation at the vacuum region using the least squares method and extrapolation toward the thin film, as shown in fig. 1(b). Using this procedure, the potential distribution at the interface was reproducibly retrieved. The phase shift for a-Ge thin film was determined to be approximately 0.5 rad, indicating that the average inner potential was 18.4 V.

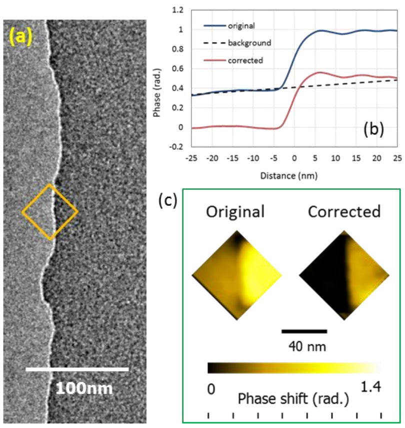

Figure 1 (a) The TEM image of the interface between a-Ge thin film and vacuum. (b) Phase profile at the interface, blue curve corresponds to the original phase and dashed line, to the linear background. Red curve was obtained by subtracting the background from the original phase profile. (c)The original and corrected phase maps obtained from the narrow region indicated in orange in (a).