Type of presentation: Poster

ID-12-P-2742 Charge density distribution in an atom probe needle measured using electron holography without mean inner potential effects.

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Since atom probe tomography (APT) utilizes atom-by-atom field evaporation of a sharp needle by an applied voltage, it is important to know the electric field distribution around the tip with nm spatial resolution for successful reconstruction. Here, we use off-axis electron holography to measure the electric field around an electrically biased Fe needle that contains yttrium oxide nanoparticle inclusions. The electric field was generated by applying a voltage between the needle and a counter-electrode that was placed coaxially with the needle at distance of ~400 nm from it. The results (Fig. 1) were interpreted both by fitting the recorded phase shift to a simulated phase image modeled using two lines of constant but opposite charge density [1] (Figs. 1 b, c) and by using a model-independent approach that involves contour integration of the phase gradient to determine the charge enclosed within the integration contour [2] (Fig. 2a). Both approaches required subtraction of the magnetic contribution to the recorded phase shift, which was achieved by calculating the difference between phase images recorded at applied bias voltages of 0 and 5 V. This approach also automatically resulted in elimination of the mean inner potential (MIP) contribution to the phase shift, which was found to be essential for the latter (model-independent) approach for the present sample. Figure 2 shows cumulative charge profiles along the needle measured using the two approaches, which are consistent with each other, with the model-independent approach revealing the presence of charge accumulation at the apex of the needle. (The black line has a steeper slope in the figure). On the assumption of cylindrical symmetry, the three-dimensional electrostatic potential and electric field around the needle could be inferred from the results, as shown in Fig. 3.

[1] G. Matteucci et al. Ultramicroscopy, 45(1): 77 – 83, 1992.

[2] C. Gatel et al. Phys. Rev. Lett., 111: 025501, 2013.

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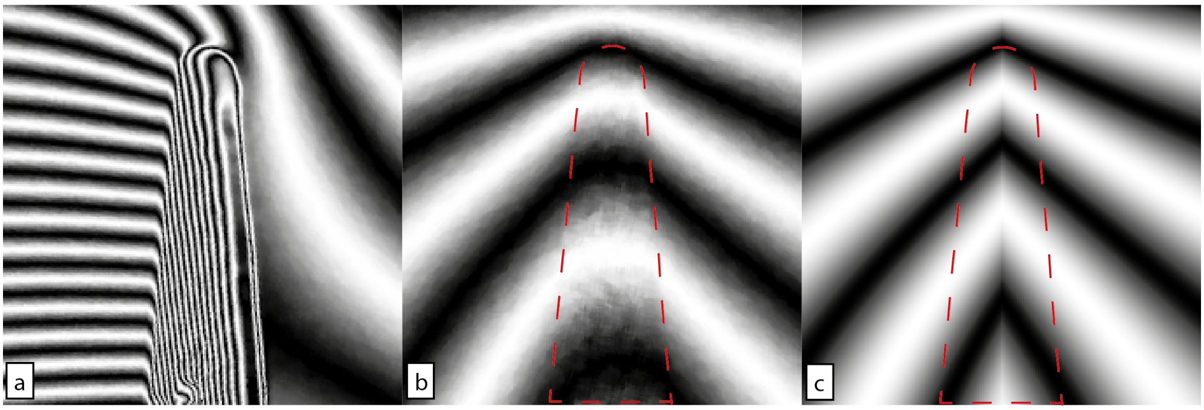

Fig. 1: Equiphase contours corresponding to a) an original phase image recorded from the needle; b) the difference between phase images acquired at two different bias voltages; c) a best-fitting model-dependent simulation to the result shown in b).

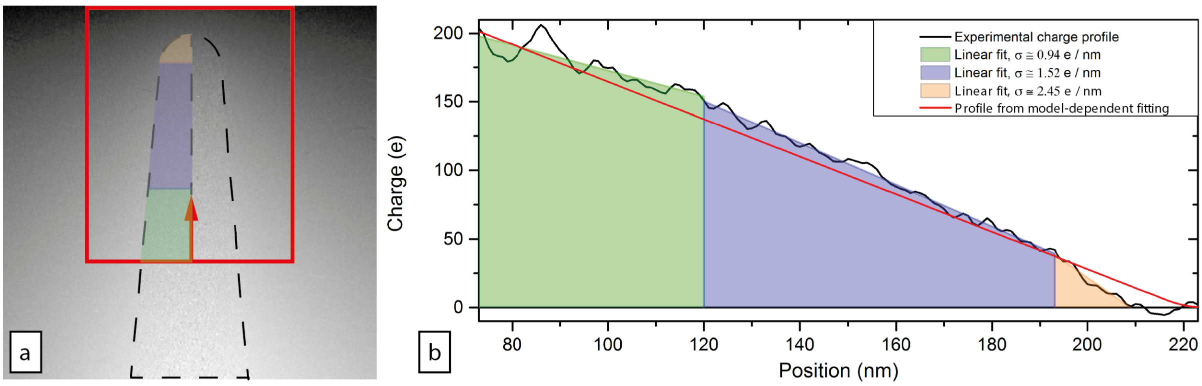

Fig. 2: a) Illustration of the use of an integration contour in the model-independent approach. b) Cumulative charge profiles measured using the model-independent (black) and model-dependent (red) methods.

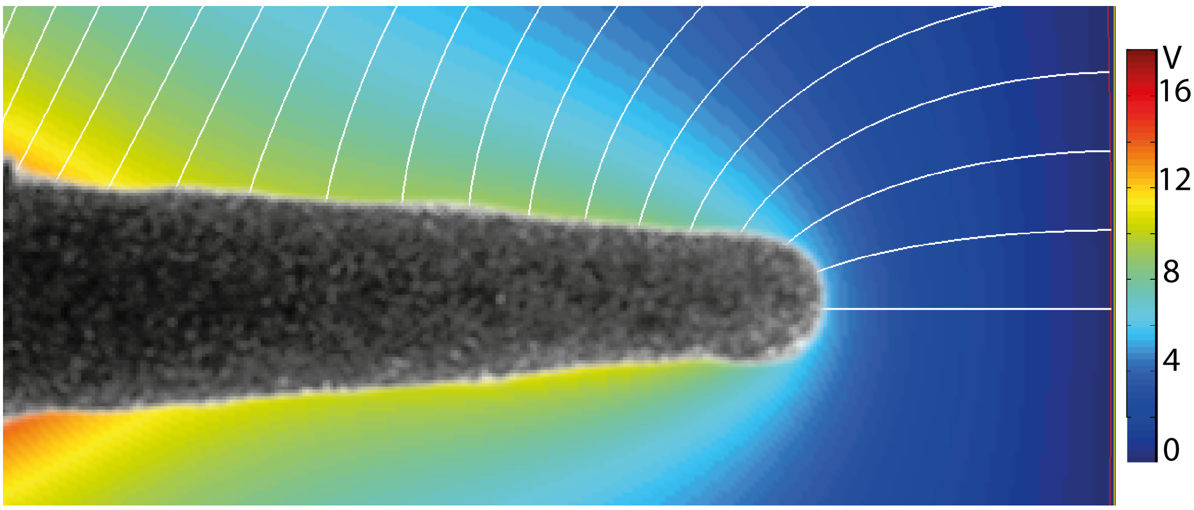

Fig. 3: Central slice of the three-dimensional distribution of electrical potential (colours) and electric field (white lines) around the needle, inferred from the results shown in Fig. 2.