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Electron Holography on Electric Field Variations with Electric Current

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While electron holography has been extensively carried out for quantitative analysis of magnetic flux distribution [1], in this talk application of electron holography to electric field analysis, especially observation of electric field variations with electric current will be presented. The electron holography experiment was performed using a JEM-3000F transmission electron microscopy (TEM) system equipped with a biprism and a magnetically shielded objective lens [2]. Voltage and electric current were applied by utilizing a double-probe piezodriving holder which was developed by the present author and his colleagues [3].

Figure 1(a) shows experimental setup for field emission in a single $TaSi_2$ nanowire. Figures 1(b) is a hologram obtained with the applied voltage 50 V, and 1(c) is its corresponding reconstructed phase image. In the reconstructed phase image, the irregular-contrast region can be seen between the W anode and $TaSi_2$ nanowire as outlined by green lines. Through the comparison between the observation and simulation, it is concluded that the irregular-contrast results from the fluctuation of electric potential in the nanowire due to the ballistic emission [4].

Figure 2(a) shows a hologram that indicates the interference fringes around a sciatic nerve tissue that comprises three microfibrils entangled with one another. In the reconstructed phase image (b), there are some irregular contrasts that correspond to electric potential fluctuation [5]. In the reconstructed amplitude image (c), the contribution of the static electric potential distribution due to the charged specimen is removed, and simple dark contrasts which form several circuits are observed. Eventually, it is clarified that the dark contrast circuits correspond to the orbits of electron-induced secondary electrons around positively charged microfibrils of sciatic nerve tissues [6].

Figure 3(a) shows the experimental setup for electric field analysis of Ag-based conductive adhesive. Figures 3(b) and 3(c) show the reconstructed phase images which are obtained before and after supplying a large electric current of 1 μA, respectively. It is noted that the spacing of contour lines is markedly inhomogeneous in Fig. 3(c), e.g. the contour lines are denser in the region indicated by the circle. It is clarified that these inhomogeneous potential distribution results from the enhancement of local conductivity due to the supply of the electric current [7].

The above results clearly demonstrate that electron holography coupled with a field control technique utilizing a double-probe piezodriving holder is quite useful to analyze the local electric field variations with electric current. The present study has been carried out with the present author's colleagues, i.e., Dr. Y. Murakami, Dr. Z. Akase, Dr. J.J. Kim, Dr. W. Xia, Dr. K.H. Kim and Dr. N. Kawamoto. The electric field analyses around a $TaSi_2$ nanowire and charged microfibrils of sciatic nerve tissues were performed in collaboration with Professor L.J. Chou's group in National Tsing Hua Univ., Taiwan and Professor S. Ohno's group in Univ. of Yamanashi, respectively.

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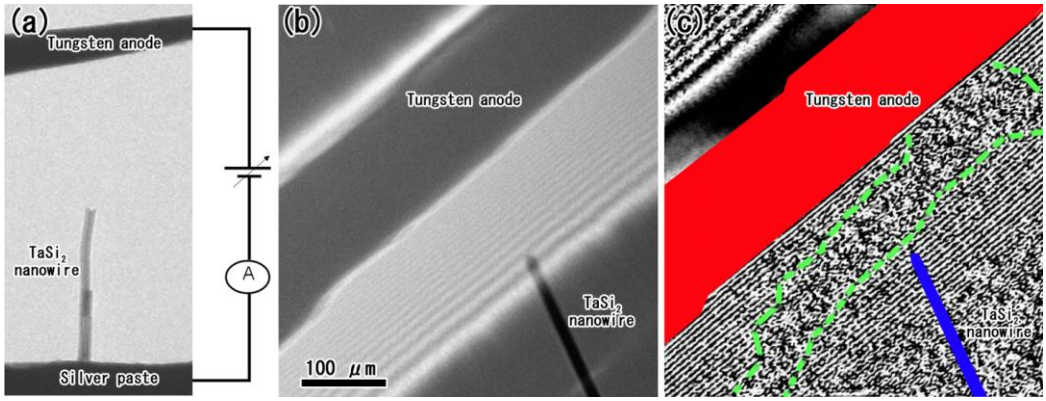

FIG. 1. (a) Experimental setup for field emission in a single $TaSi_2$ nanowire. (b) Hologram obtained with the applied voltage 50 V. (c) Corresponding reconstructed phase image.

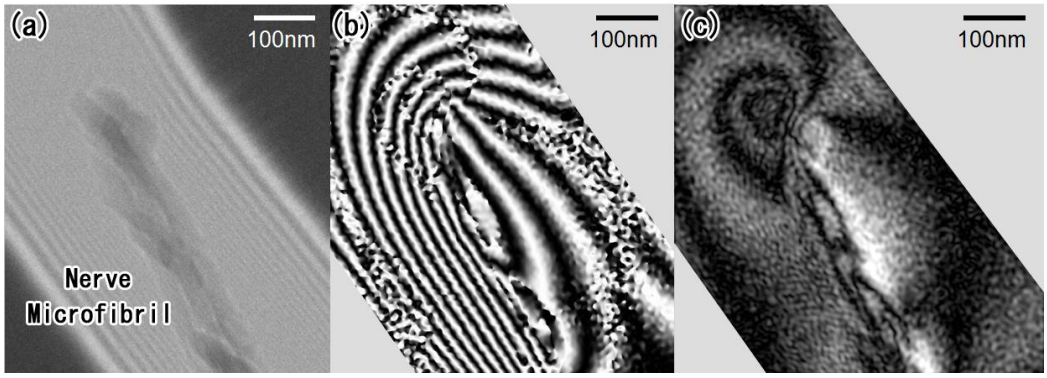

FIG. 2. (a) Electron hologram of tangled microfibrils of a sciatic nerve tissue. (b) Reconstructed phase image. (c) Reconstructed amplitude image.

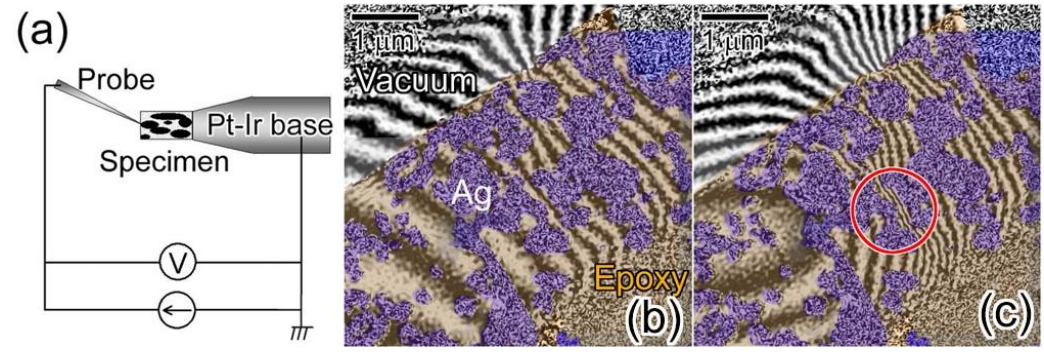

FIG. 3. (a) Experimental setup for electric field analysis of Ag-based conductive adhesive. (b) and (c) are the reconstructed phase images obtained before and after supplying a large electric current of 1 μA, respectively.