Imaging by Electrochemical Scanning Tunneling Microscopy and Deconvolution Resolving More Details of Surfaces Nanomorphology

Jens E.T. Andersen

Department of Chemistry, Technical University of Denmark, Kemitorvet building 207, DK-2800 Kgs. Lyngby, Denmark, jeta@kemi.dtu.dk

Upon imaging, electrochemical scanning tunneling microscopy (ESTM), scanning electrochemical microscopy (SECM) and *in situ* STM resolve information on electronic structures and on surface topography. At very high resolution, imaging processing is required, as to obtain information that relates to crystallographic-surface structures.

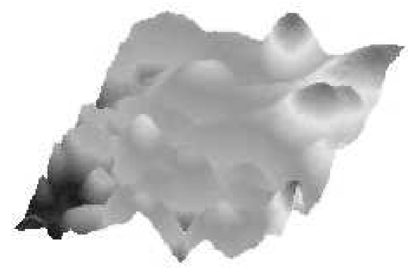
Within the wide range of new technologies, those images surface features, the electrochemical scanning tunneling microscope (ESTM) provides means of atomic resolution where the tip participates actively in the process of imaging. Two metallic surfaces influence ions trapped in the interface of imaging and the independent-electrochemical control opens new pathways of studying fundamentals of electrocrystallisation and of adsorption kinetics. In addition, the ESTM instrument itself may be applied as a tool of nanotechnology that allows manufacture of new products, e.g., nanoelectronics and single-molecule probing.

In principle, the ESTM is capable of sub-atomic resolution but many details at this level of magnification need further treatment of recorded data before real information is obtained. Deconvolution of the data according to the instrument response may explain some of the characteristic details of the images. A large proportion of the observed noise may be explained by the scanning actions of the feedback circuitry while a minor fraction of the image details may be explained by surface drift phenomena. As opposed to the method of deconvolution, conventional methods of filtering discard some of the recorded data, as to improve the signal-to-noise ratio. By deconvolution however, all data were maintained and it is demonstrated that images of atomic resolution were sharpened considerably and shadow effects were removed in images of lower resolution. Thus, the smooth features observed in high-resolution images of metallic nanocrystallites may be effectively deconvoluted, as to resolve more details of the crystalline morphology (see figure).

Images of surface-crystalline metals indicate that more than a single atomic layer is involved in mediating the tunneling current that generates the image. Tunneling through less-conductive molecules, such as organic molecules, DNA molecules or protein molecules, may be facilitated along channels of electronic conductivity or by transfer of protons generated electrochemically at the participating surfaces.

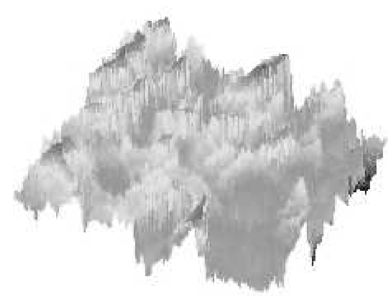
A)

- Recorded



B)

- Deconvoluted



C)

Line-scan

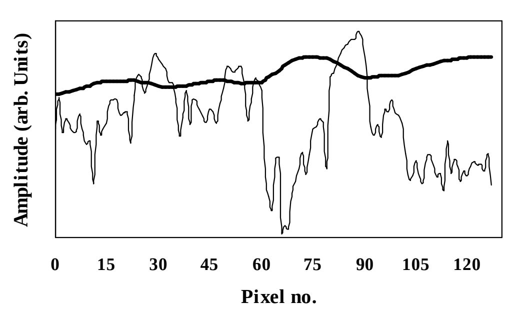


Figure. 3D-Nanomorphology of copper electrodeposited on gold at E = -400 mV (vs. Cu/Cu^{2+}) in 0.01 M H_2SO_4 and 0.005 M $CuSO_4$. (A) Original image, as recorded. Dimensions 330 nm x 330 nm. (B) Deconvoluted image. (C) Cross section of the original image (thick line) compared to the deconvoluted data that represents the real shape of the nanocrystallites (thin line).