Tip-Induced Metal Deposition for Nanostructuring Electrode Surfaces

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Electrochemists are making increasingly use of scanning probe microscopes (STM or AFM) as a tool for nanostructuring electrode surfaces, e.g., by creating surface defects at preselected positions with the tip of an STM, which then can act as nucleation centers for metal deposition [1]. Other strategies involve the local removal of an inhibiting overlayer with the tip of an STM or AFM to allow metal deposition at defined areas [2,3], or use STM tips as a spatially confined source for metal ions to be deposited at the surface right underneath the tip [4].

Over the last 10 years we have developed a process for nanostructuring electrode surfaces by small metal clusters, which are generated by a direct material transfer from the tip to the substrate via a so-called jump-to-contact [5,6]. Since the approach of the metal-loaded tip to the substrate surface as well as the lateral tip position are controlled by a computer, the nanodecoration of surfaces can be performed very fast (up to several hundred clusters per second) and very reproducibly (see Fig. 1) [7].

After describing the mechanism of tip-induced metal deposition, various examples of a computer-controlled nanodecoration of bare and thiol-covered surfaces will be presented. Systems are shown, for which the jump-to-contact occurs with metal from the substrate, leaving nanosized holes in the surface (e.g., Ni tip and Au substrate). The surprisingly high stability of the metal clusters against anodic dissolution is discussed [8] and preliminary STS data are shown for Cu clusters on Au(111) [9]. We will report on first attempts to combine STM and SECM (scanning electrochemical microscope) to study quantitatively the electrochemical reactivity of tip-induced metal clusters.

References
