Electrochemical Scanning Probe Microscopy

Figure 1. From left to right: Digital Instruments MultiMode SPM platform configured for Electrochemical AFM; an ECM platfor m configured for Electrochemical STM; an LFM platform configured for SECPM. Other configurations look nearly identical to one of these three.

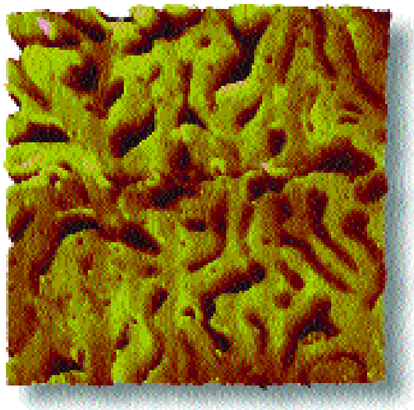

Figure 2. SECPM constant-potential mode image of Sn60Pb40 alloy in Glycerol at open circuit potential using uncoated Pt-Ir tip at potential setpoint of 100mV. The open circuit potential is -520mV vs. Pt quasi reference electrode. Scan rate: 0.5Hz, 5μm scan.

Veeco Instruments Inc. offers three different options for performing electrochemical scanning probe microscopy (SPM), powered by the Digital Instruments NanoScope® SPM controllers: Scanning Electrochemical Potential Microscopy (SECPM), Electrochemical Scanning Tunneling Microscopy (ECSTM), and Electrochemical Atomic Force Microscopy (ECAFM). Each of these options is available on two or three different SPM platforms, as listed (Figure1). Each option includes a bipotentiostat/galvanostat, one or more liquid cells, as well as liquid and electrode attachments. Veeco's ECSPM, together with the integrated electro-chemistry/SPM software, offers researchers the spatial resolution, flexibility and ease of use to study a wide range of electro-chemical processes (such as UPD, adsorption/desorption, corrosion, electro-plating) *in-situ* and real-time.

Scanning Electrochemical Potential Microscope (SECPM), is the newest electrochemical SPM, a patented technique exclusively available from Veeco Instruments. SECPM offers *in-situ* imaging or potential mapping of the electrode surface with nanometer-scale resolution (Figure 2). The electrochemical potential changes with distance across the electrical double layer at solid/liquid interfaces. SECPM measures the potential difference between its potentiometric probe and the sample in an electrolyte solution or a polar liquid. Moreover, STM is integrated with SECPM, offering combined power, flexibility and comparison of images and data captured with the two techniques. SECPM includes a Bipotentiostat/galvanostat, liquid cell and attachments and is available on two Digital Instruments STM platforms: the MultiMode™ and LFM (Figure 1). See the SECPM datasheet for more details.

Electrochemical Scanning Tunneling Microscope (ECSTM) allows real-time *in-situ* STM imaging with atomic and molecular resolution of the electrode surface in solution under electrochemical control (Figures 3-4). ECSTM includes a Bipotentiostat/galvanostat, liquid cell and attachments and is available on two Digital Instruments SPM platforms: the MultiMode and LFM (Figure 1). The MultiMode SPM covers all LFM functions, and supports TappingMode™ AFM.

Electrochemical Atomic Force Microscope (ECAFM) allows real-time *in-situ* AFM imaging with nanometer resolution of electrode surface in solution under electrochemical control (Figure 5). ECAFM includes a potentiostat/galvanostat, liquid cell and attachments and is available on the ECAFM and LFM platform (Figure 1). Both cover all LFM functions and support TappingMode™ AFM.

Veeco's Bipotentiostat/galvanostat enables researchers to control electro-chemical processes either potentiostati-cally or galvanostatically. Electrochemical control and data acquisition is integrated into the Digital Instruments NanoScope SPM software. Topographical and electrochemical data are recorded simultaneously, thus correlation of the two is readily available. Alternatively, an external potentiostat may be used.

Summary

Our focus on ease of use, performance, versatility and innovation have made the Digital Instruments Electrochemical SPMs the most productive available on the market, with more peer-reviewed publications than any other commercial electrochemical SPMs. Each Electrochemical SPM option may be purchased as a complete system, or add-ons to an existing, compatible system. The flexibility and modularity provided by the Digital Instruments Nanoscope digital feedback control system allows the electrochemical microscope to be added easily. Further flexibility can be provided with the optional Signal Access Module™ which provides easy access to numerous input and output signals of the SPM control system.

For descriptions of other Electrochemical Scanning Probe Microscopy components and features, please visit the Digital Instruments MultiMode SPM page of www.veeco.com. Accessories/Options include: Electrochemistry STM/AFM Converter, Electronic and Thermal Applications Modules, Signal Access Modules, STM and Low-Current STM Converters, Temperature Accessories, Fluid Imaging Cells, as well as NanoScope IIIa and IV Controllers.

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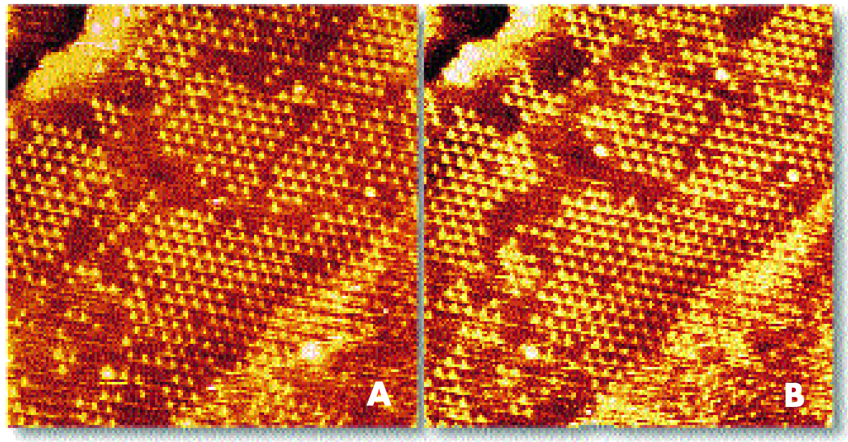

Figure 3. STM images of Pt(111) electrode in 0.1mM KCN + 0.1M $KClO_4$ taken at 0.6V vs. RHE. Image A was taken 20 seconds before image B. Same portion of the K^+ cations in A disappeared, while the remainder appeared at the low left-hand corner of B, forming new $(2\sqrt{3} \times 2\sqrt{3})$- R30° domains. 30nm scans.

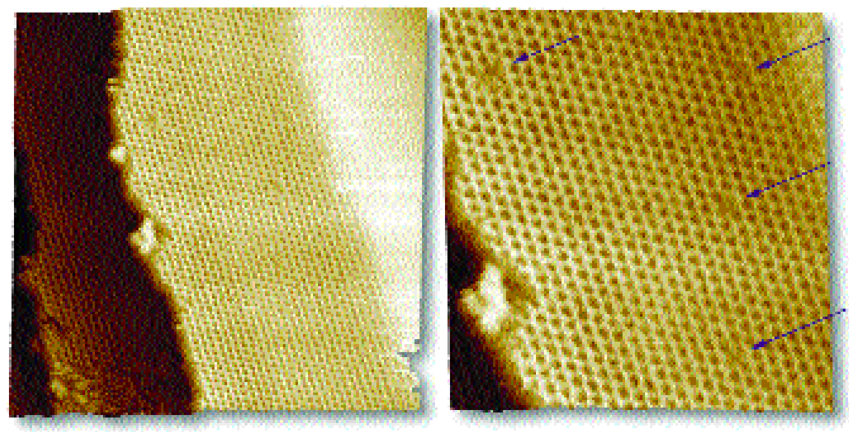

Figure 4. *In-situ* STM image (20nm scan) and zoom of $(\sqrt{3} \times \sqrt{3})$R30 adlayer structure formed by underpotential deposition (UPD) of a sub-monolayer of Cu on Au(111)/mica in 0.1M H_2SO_4 + 5mM $CuSO_4$ at -105mV vs. Ag/AgCl. Arrows locate four atomic point defects.

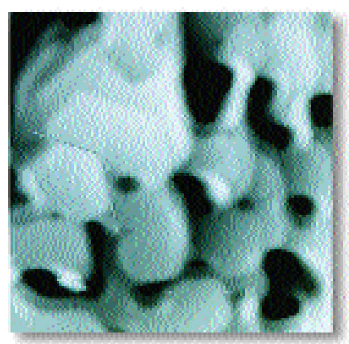

Figure 5. *In-situ* AFM image of overpotential deposition of Cd on Cu(111) surface obtained in the solution containing 2mM $Cd(ClO_4)_2$ + 0.1M $HClO_4$ at -580mV vs. NHE. Cd hcp crystal structure with sharp edges is clearly visible. The two adjacent lines drawn on the image form an angle of 120°. 650nm.

Veeco Instruments, Inc.
112 Robin Hill Road
Santa Barbara, CA 93117
Find out more at www.veeco.com
805-967-1400 • 1-888-24-VEECO

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