New Strategies towards Micro- and Nanobioanalytics

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Electrochemical processes at the solid/liquid, liquid/liquid, and gas/liquid interface play a major role in many surface reactions ranging from corrosion processes to biological studies at cell surfaces. The investigation of such interfacial processes requires analytical techniques providing molecular selectivity, high sensitivity, and the appropriate temporal/spatial resolution. Recent developments in scanning probe microscopy (SPM) are focusing on the combination of individual SPM techniques, or on the combination with optical techniques to expand the information content accessible at the nanoscale. Examples of hyphenated surface analytical techniques are the combination of atomic force microscopy with scanning electrochemical microscopy (AFM-SECM) [1,2] and the combination of AFM with fluorescence microscopy or spectroscopy [3,4]. Our research activities in AFM-SECM are focused towards high-resolution electrochemical imaging, novel electrode materials such as integrated boron-doped diamond electrodes [5], conductive polymer electrodes and integrated sensing schemes.

The combination of AFM with fluorescence microscopy (FM) or spectroscopy is particularly interesting in life sciences. Cells sensing mechanical stress usually respond to such stressors with proliferation or differentiation. We developed a stretching device, which is implemented in the AFM/FM setup, and hence, allows applying a controlled mechanical stimulus to cells during *in-vitro* experiments while simultaneously providing a localized or spatially resolved determination the concentration profiles of signaling molecules such as ATP and/or mapping changing in cell morphology. Molecular specific information of electrochemical processes can be obtained by combining IR spectroelectrochemistry using *in-situ* infrared attenuated total reflection spectroscopy (IR-ATR) with AFM as simultaneous spectroscopic access to surface processes during topographical imaging is provided. An overview on the state-of-the-art, current challenges, and the future potential of such hyphenated analytical surface techniques will be presented, and complemented by selected examples relevant to biomedical and material sciences.

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